3D Printed Dish Feeds

KN0WS

Credit up front to W1GHZ

Paul Wade

Everything I know about circular feeds is from his on-line book or his articles

(Understanding that he often is doing analysis of the prior work of others)

Some folks who have done 3D antenna work

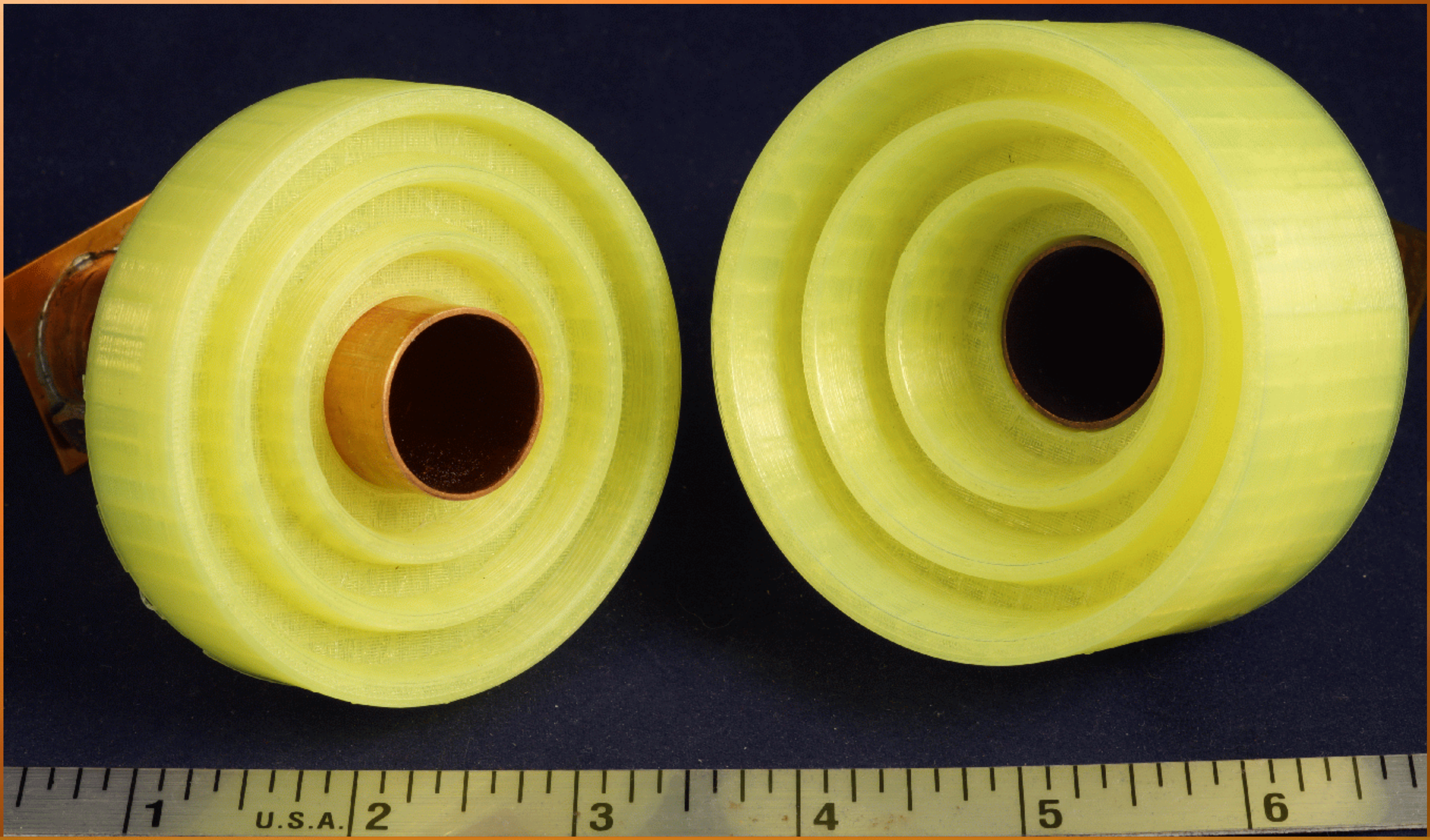
-Paul Wade - QST article January 2021

-W2HRO prints housing for patch feeds

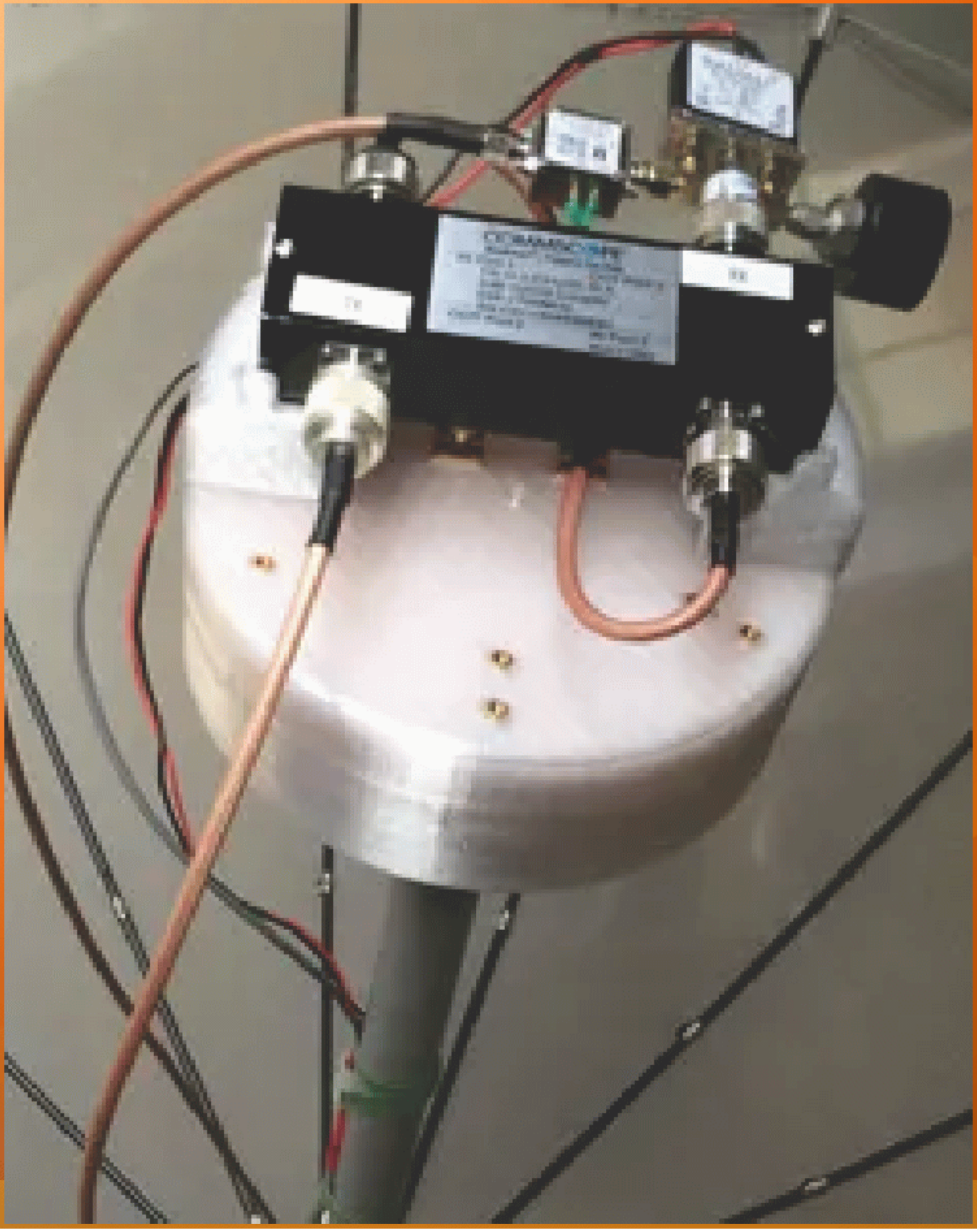
-various printed helical FPV antennas

-122 Ghz Cassegrain reflector (W5NYV)

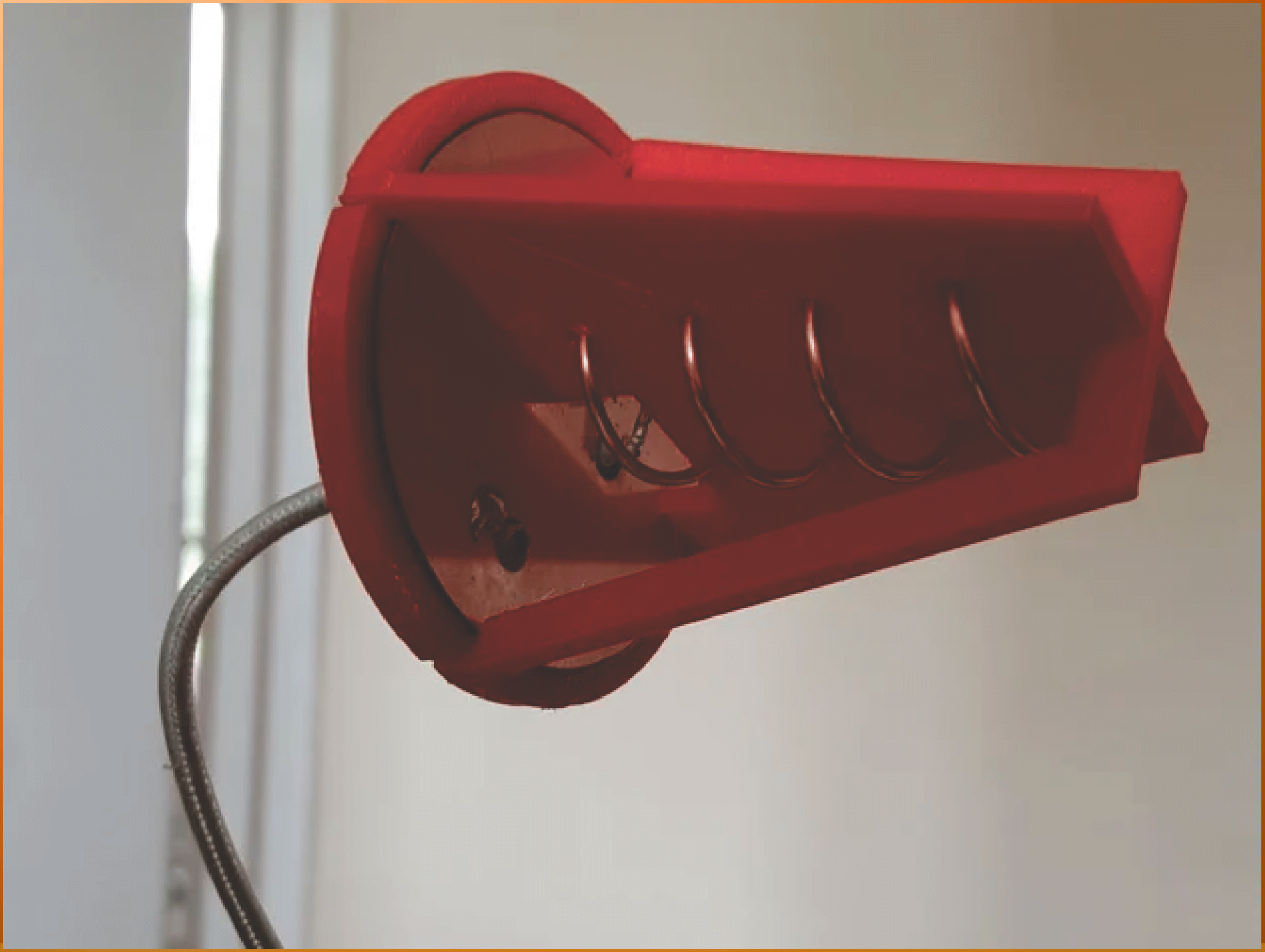
W1GHZ printed chaparral chokes

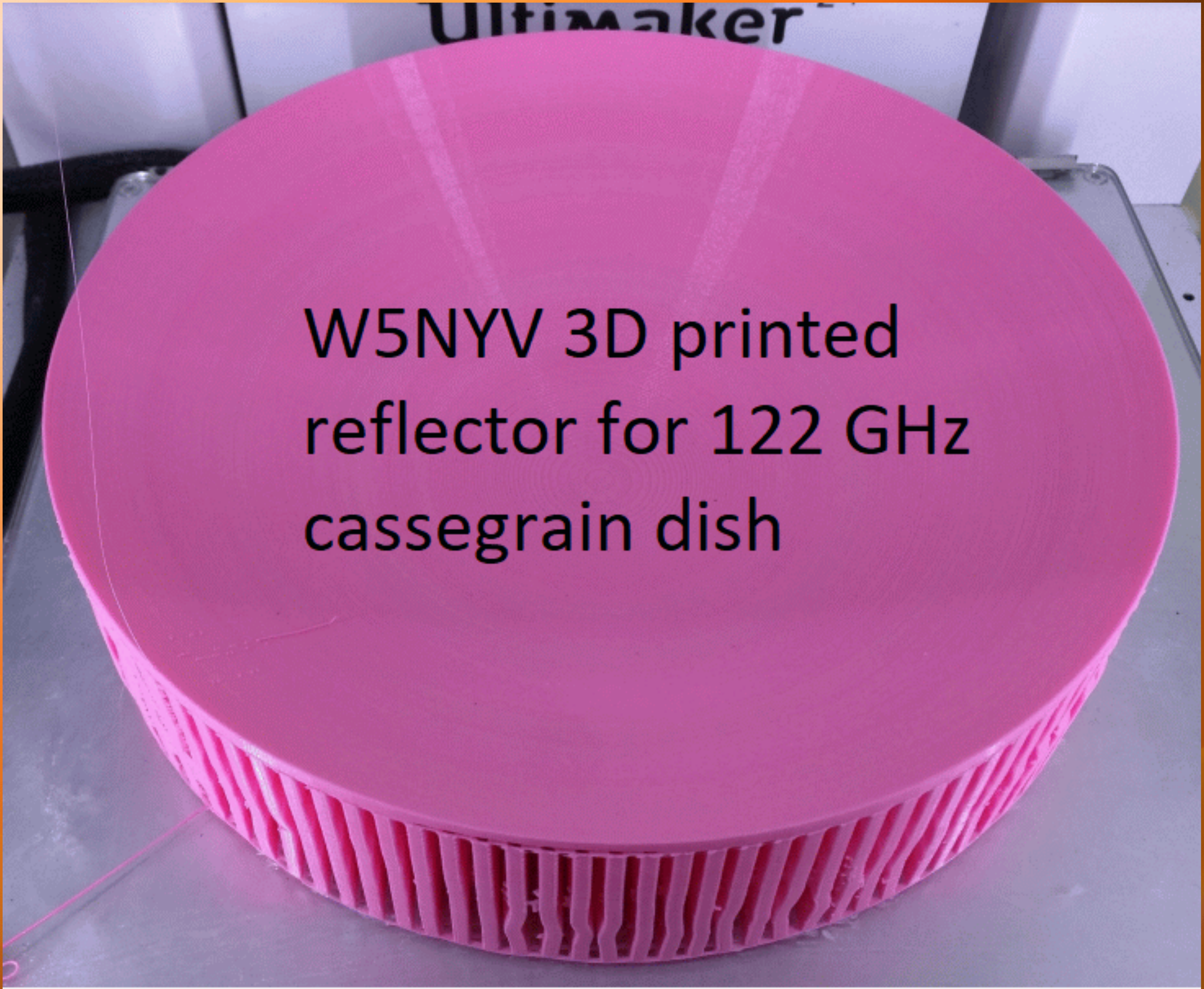


W2HRO patch feed housing



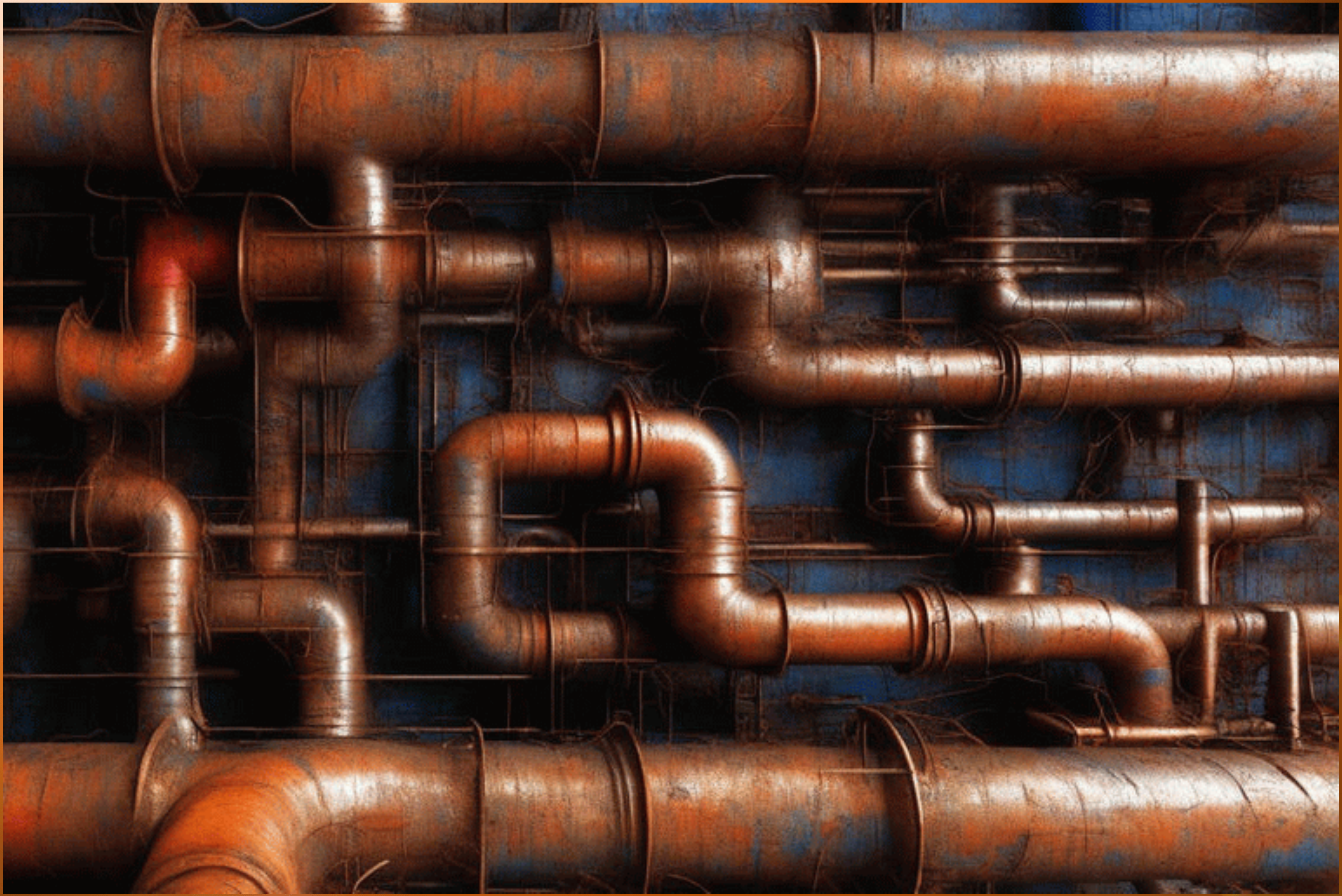
Example of a “first-person view” 5.8 Ghz helical feed





W5NYV 3D printed reflector for 122 GHz cassegrain dish

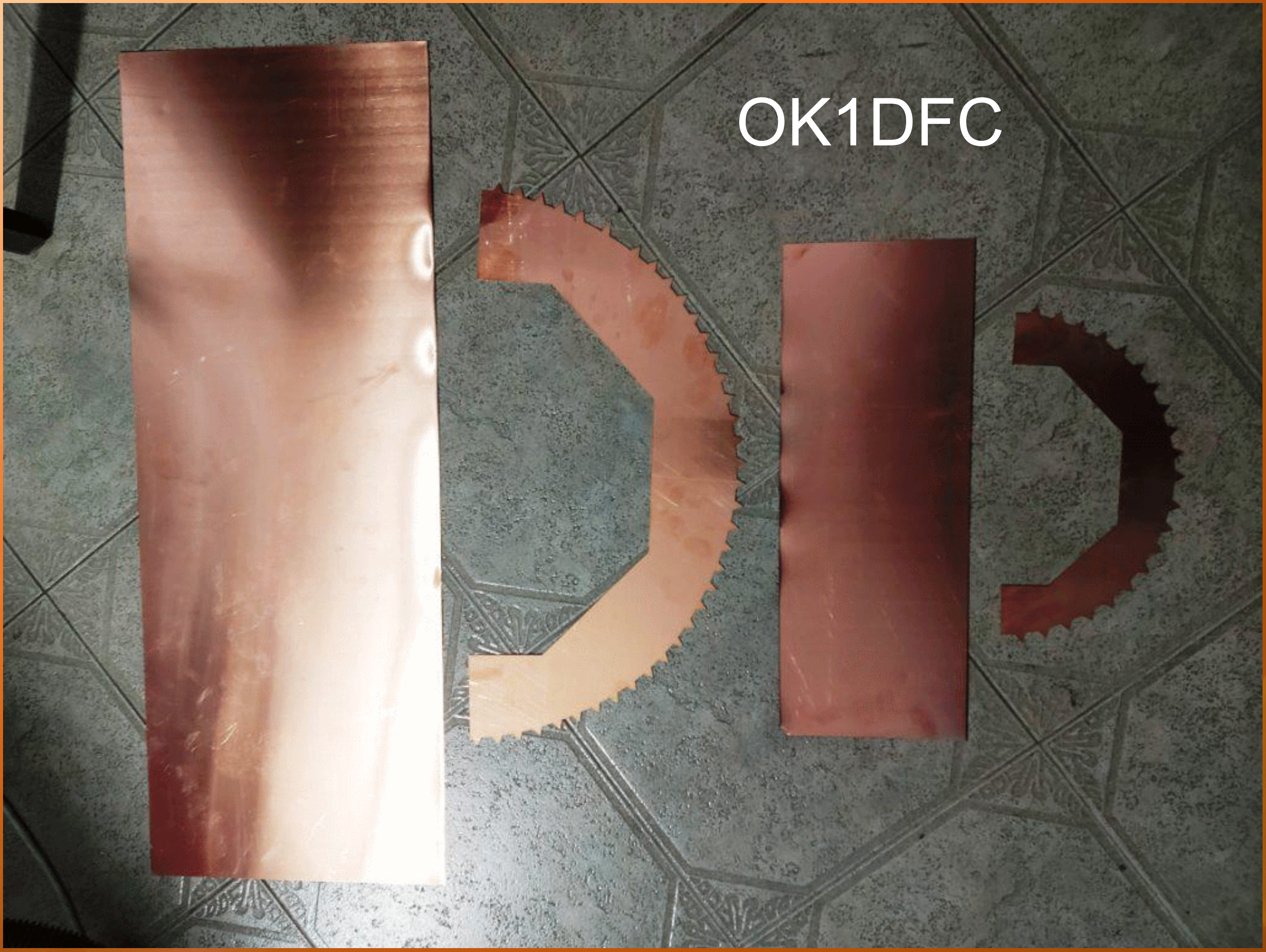
COPPER!



G3PHO used available plumbing fittings from UK

(tubes, transitions...)

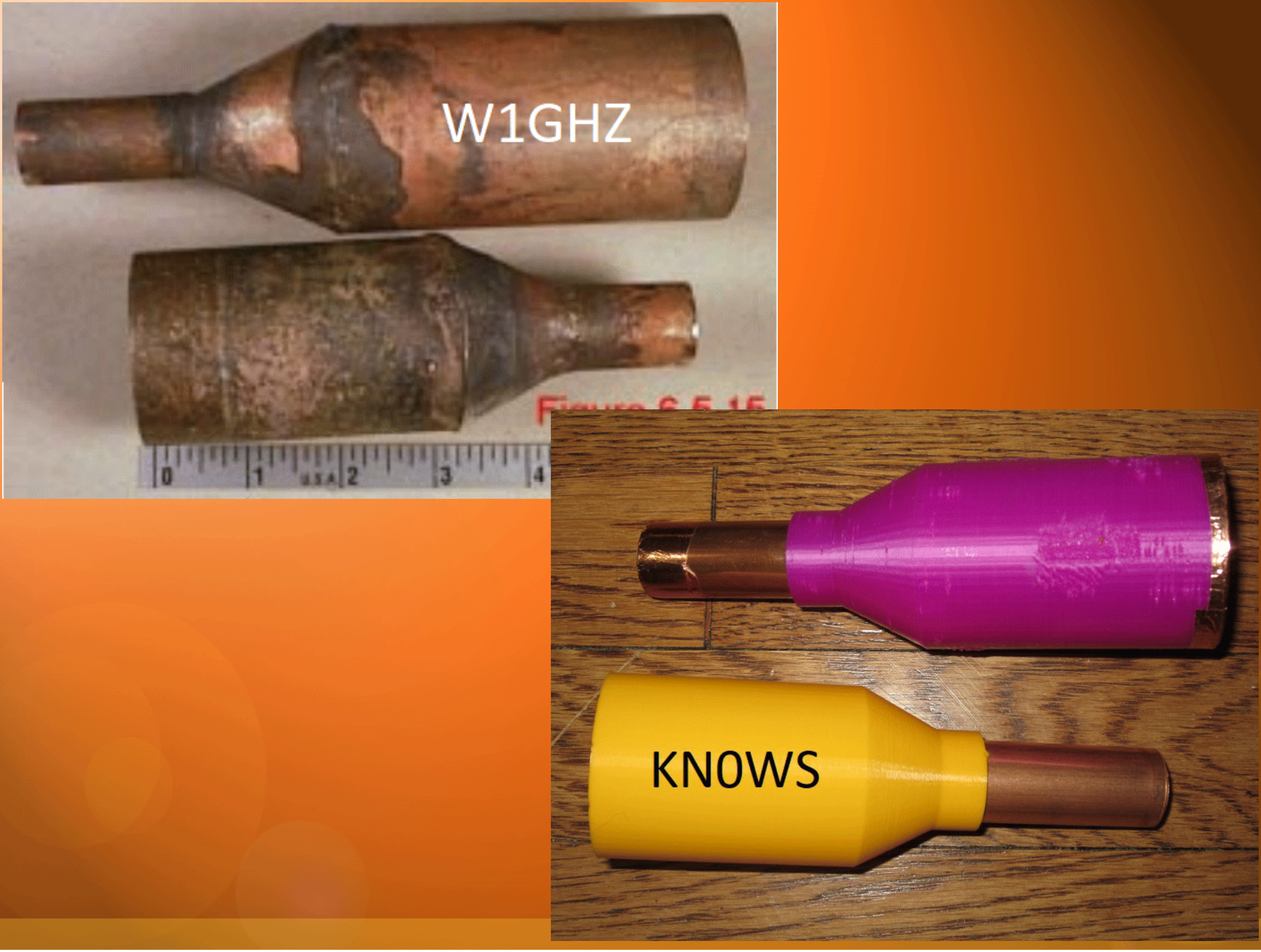
Fabricated feeds



OK1DFC

3D printing can simplify

- Portions of a feed can be made without metal work (if that is intimidating)
- You can get precise dimensions (0.1mm)
- Pre-designed parts are easily shared


W1GHZ
Figure 6.5.15
0
1
U.S.A
2
3
4
KN0WS

You STILL need metal

- Patch feeds still need a metal patch
- Helical feeds still need metal helix
- Tx/Rx probes need to be metal
- All feeds need metal coaxial connectors
- 3D surfaces need to be metalized

Metallic painting of plastic

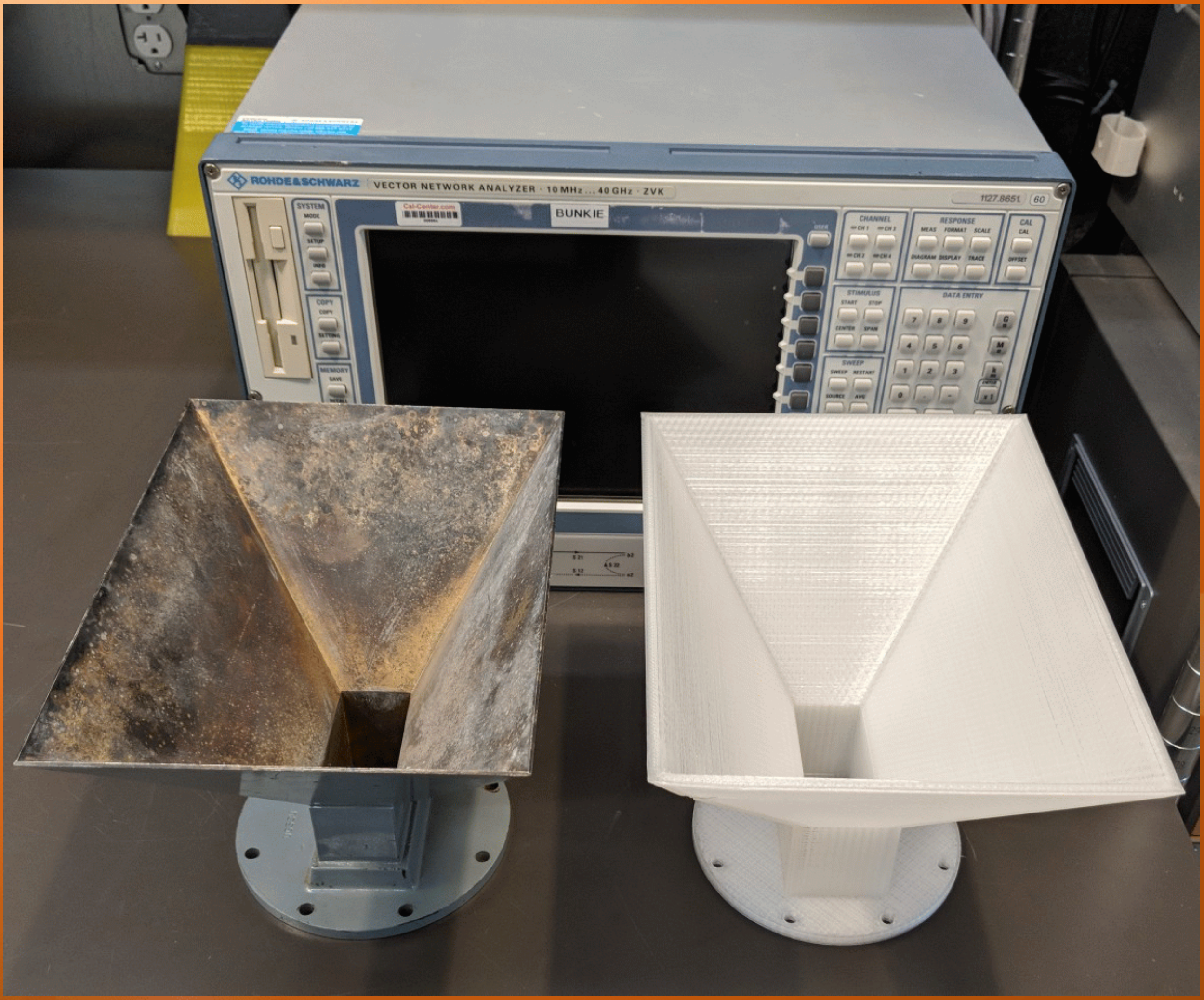
This is the standard approach that I have seen

- Some of these paints are expensive
- Requires smoothing of the surface first
- May involve toxic solvents & fumes

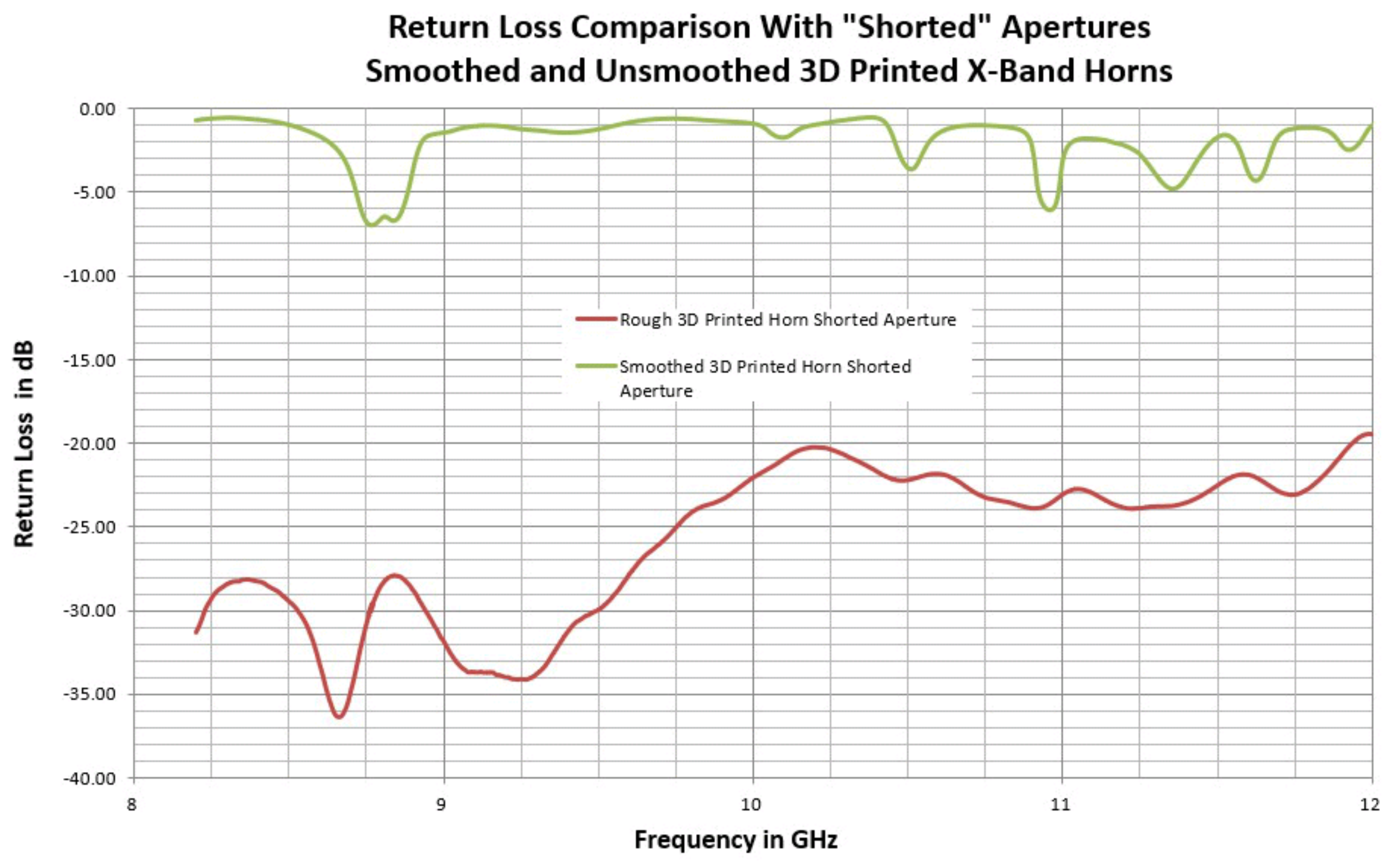
Example of Nickel conductive paint at $76 for 150 ml

MG Chemicals
841AR
SUPER SHIELD™
NICKEL CONDUCTIVE PAINT
PEINTURE DE NICKEL CONDUCTEUR
PINTURA CONDUCTIVA DE NÍQUEL
EMI/RFI SHIELDING
#841AR-150ML
150 mL ℮
RoHS
M.G. Chemicals UK Ltd. Sedgley, Dudley, England, DY3 1JA Phone +44 1663 362888
M.G. Chemicals Ltd. Burlington, Ontario, Canada, L7L 5R6 Phone 1-905-331-1396
Produced in Canada
www.mgchemicals.com
DANGER

Antenna Test Lab printed 15 dB horns to compare with metal



Un-smoothed horn had significant performance troubles

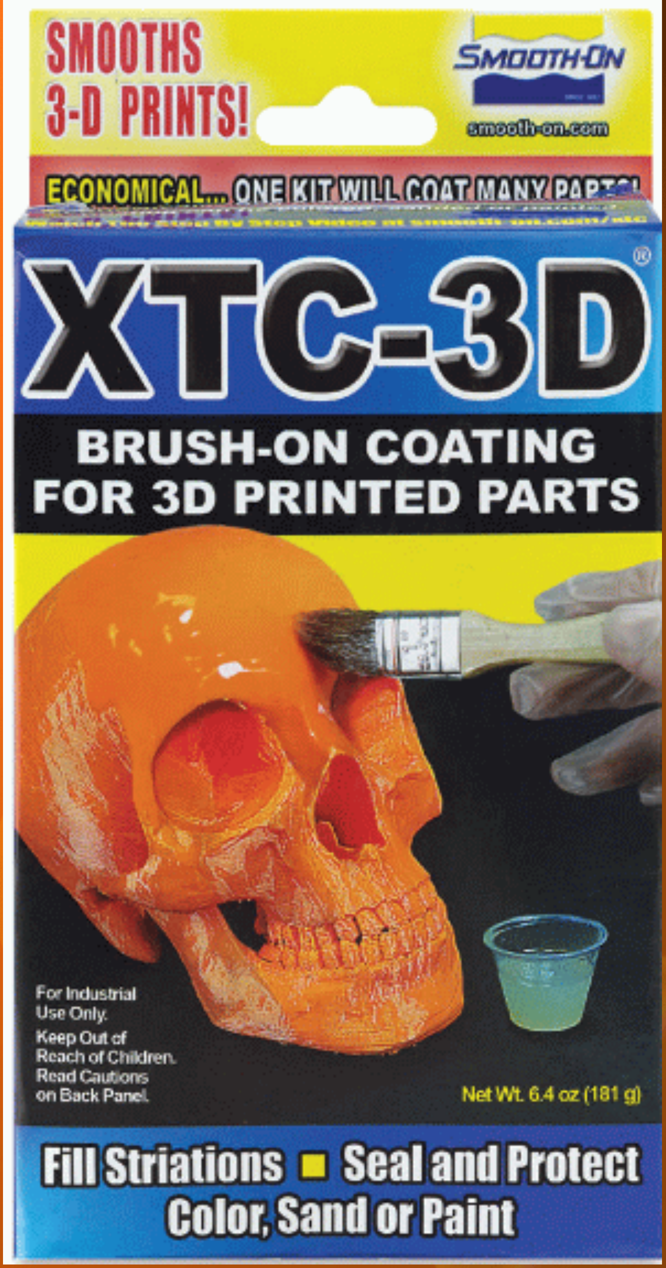


Dichloromethane

- Has been used to smooth 3D printed PLA plastic before applying metallic paint, but...

- TOXIC! “... The substance is irritating to the eyes, skin and respiratory tract... may cause vomiting... may cause effects on the central nervous system, blood, liver, heart and lungs. Exposure could cause carbon monoxide poisoning...”

As an alternative, W5NYV instead applied a “Smooth-On” epoxy layer, then lightly sanded before applying the metallic paint.



My solution?

Copper TAPE

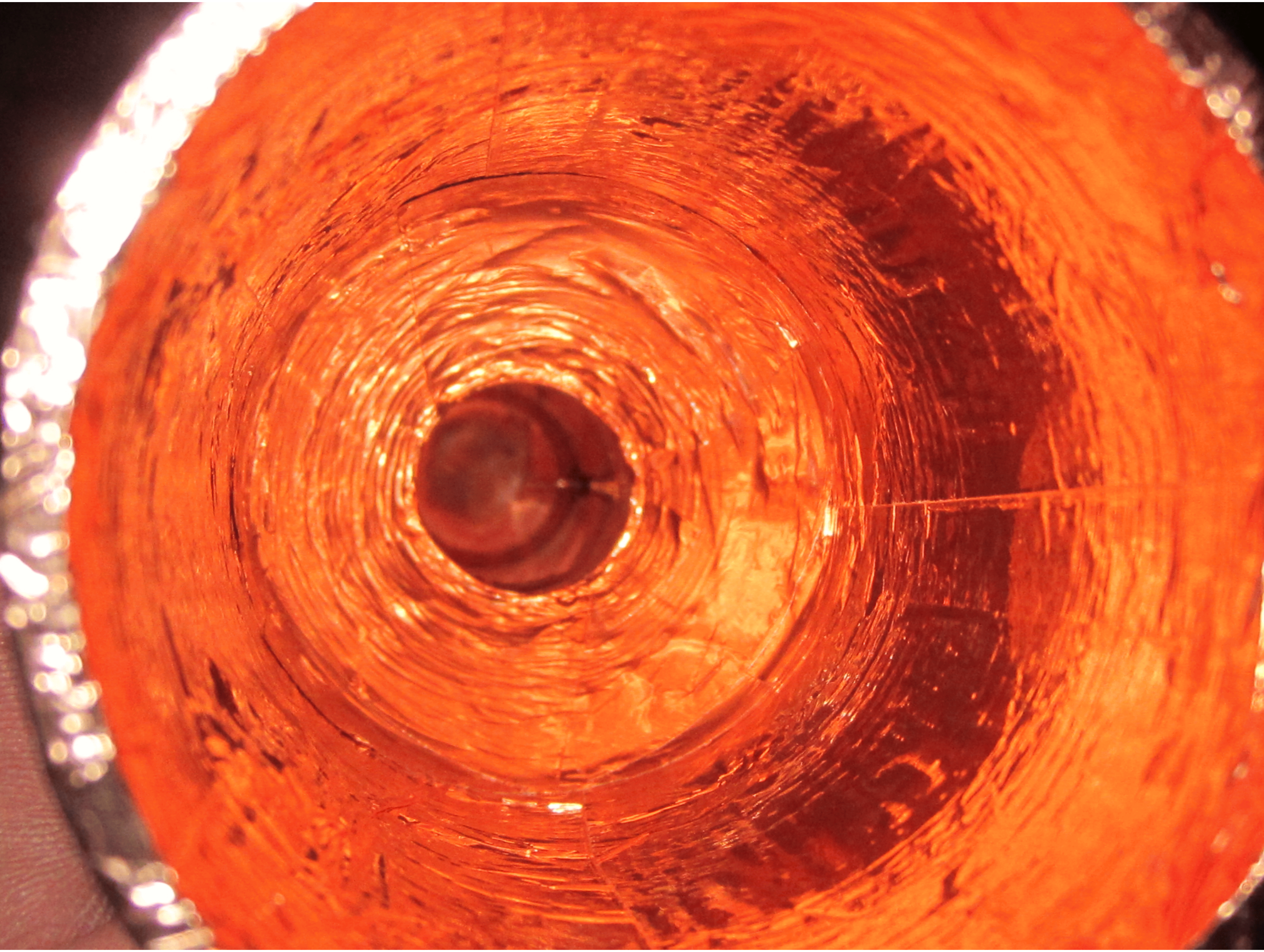
This is used to line the interior of guitar electronics compartments

Pete Townshend of “The Who” (might be only documented exception to fume-free guitar?)

(Image credit: Chris Morphet/Getty Images)

Why use copper tape?

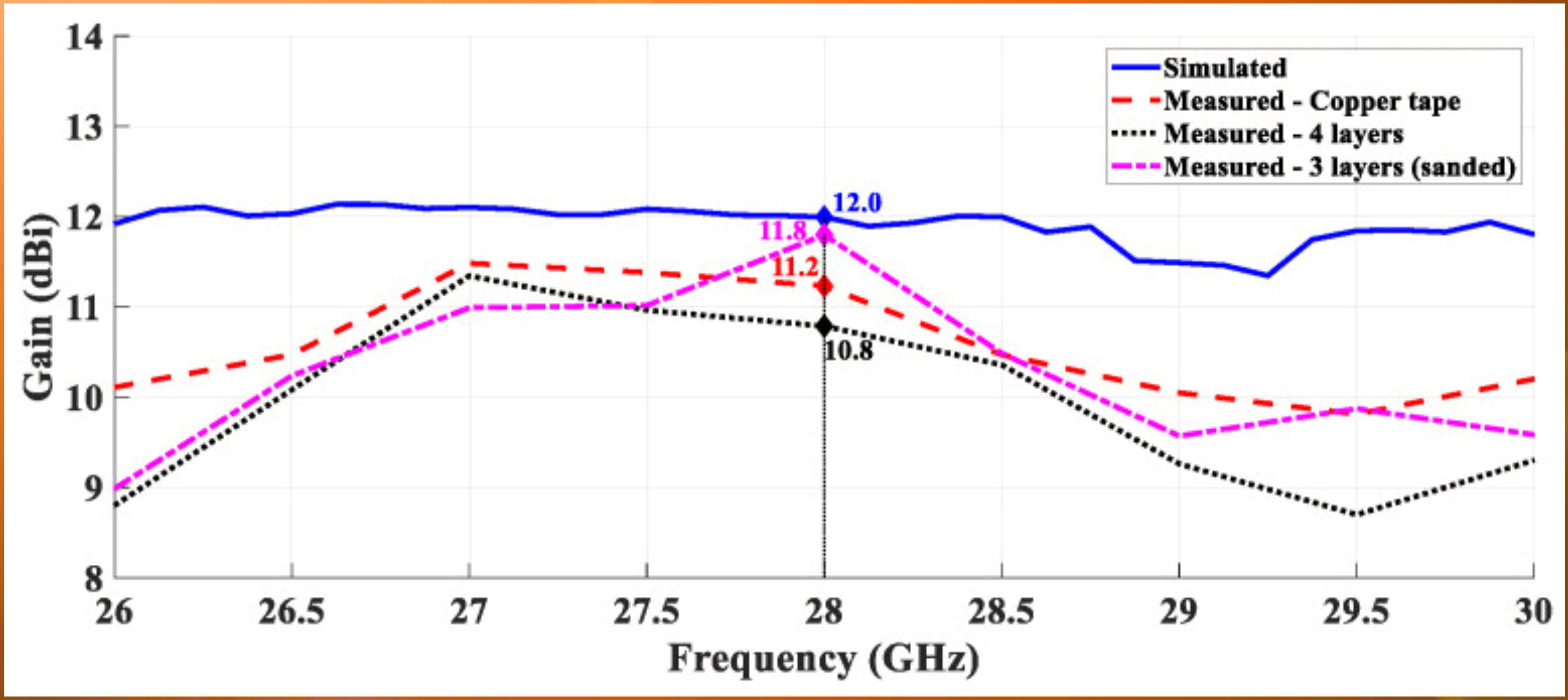
- As above, non-toxic
- Inexpensive at about $10 per roll
- It is thin, so overlapping layers OK
- I have been pleased with adhesion
- In spite of wrinkles, it seems to work



I cut the tape into rectangular or triangular pieces and overlap them.
I use a pencil to press into place.

Sensors, May 2021article

3D printed 12 dB horns for 28 Ghz with different coatings



3D feed Potential Limitations

- Delamination of tape
- Thermoplastics may melt!
- U/V explosure

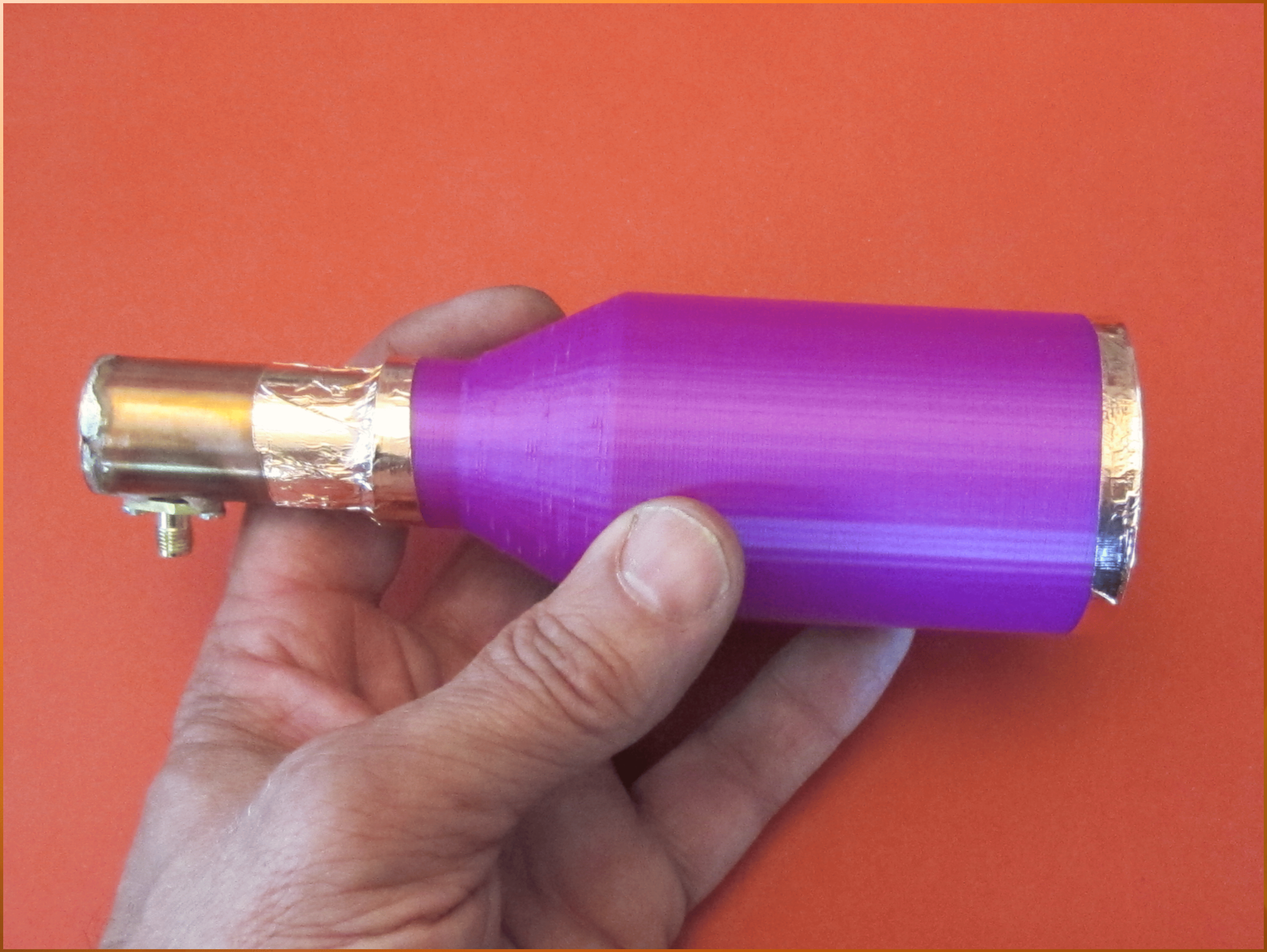
I have not seen these probems, but my gear is packed away after the weekend

Why I tried out 3D printing

My feed did not match my dish

RF Ham Design 145 deg

I printed up W2IMU for 0.68



Formulas for 10 Ghz feed from? PAUL WADE!

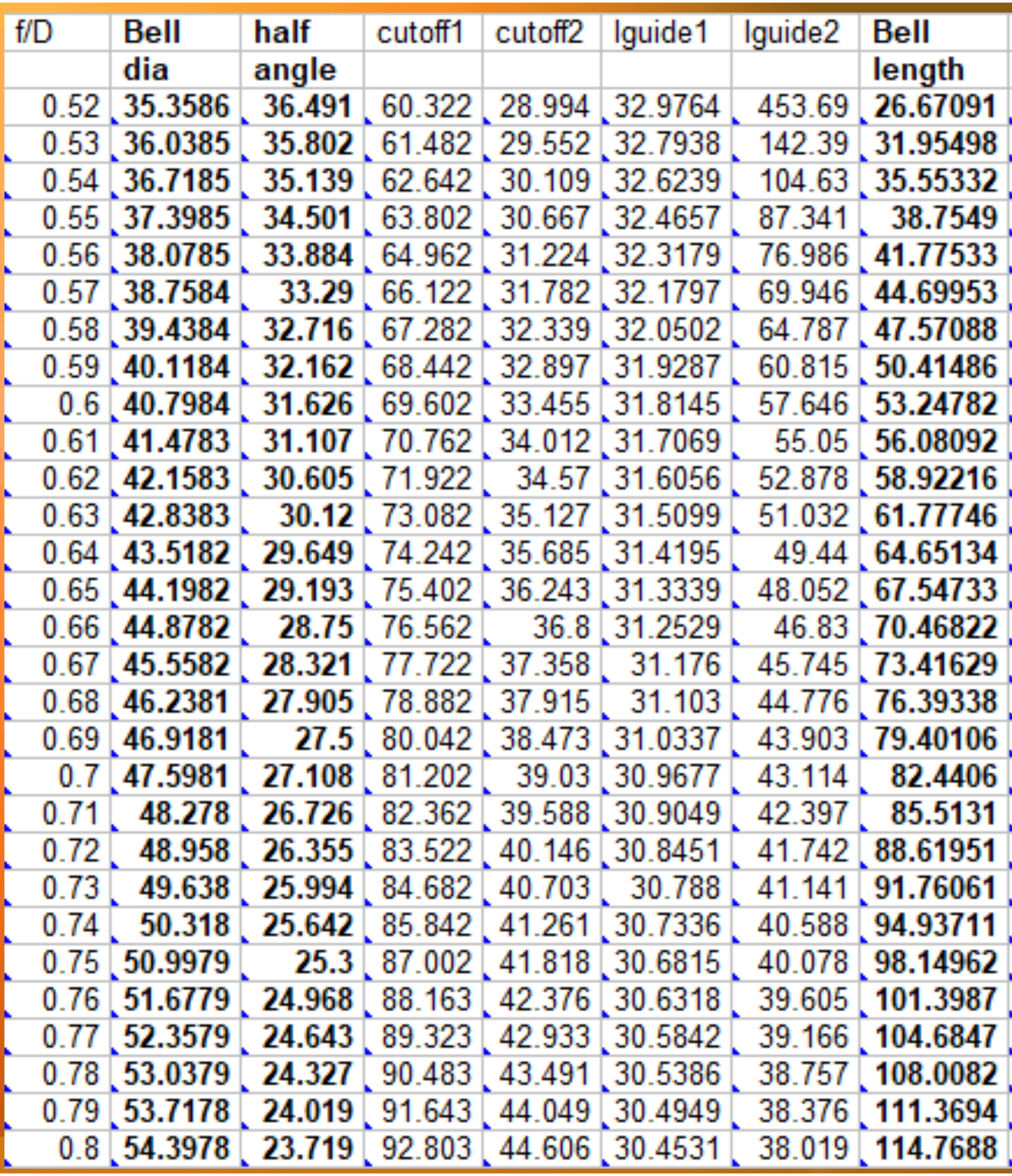
Bell diameter B = 2.35*(f/D)*lambda

Flare half-angle = 44.6 * lambda/ B

Bell length C= 0.75 / ((1/lambda g) - (1/lambda g prime))

(Lambda g is waveguide wavelength for TE11 mode and lambda prime is for TM11 mode)

A chart with dimensions for W2IMU feed for 10 Ghz band (mm)

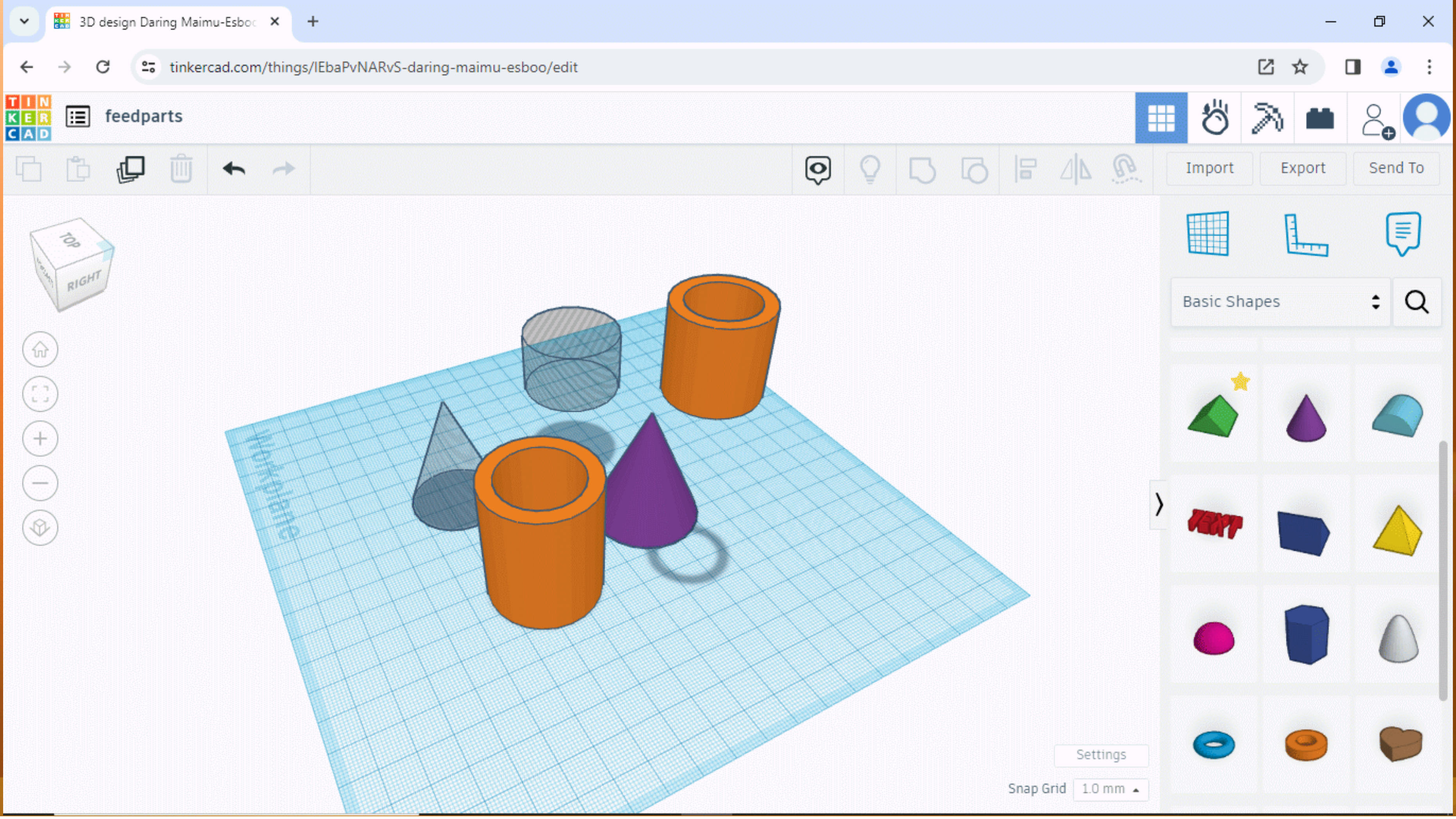


f/D	Bell dia	half angle	cutoff1	cutoff2	lguide1	lguide2	Bell length
0.52	**35.3586**	**36.491**	60.322	28.994	32.9764	453.69	**26.67091**
0.53	**36.0385**	**35.802**	61.482	29.552	32.7938	142.39	**31.95498**
0.54	**36.7185**	**35.139**	62.642	30.109	32.6239	104.63	**35.55332**
0.55	**37.3985**	**34.501**	63.802	30.667	32.4657	87.341	**38.7549**
0.56	**38.0785**	**33.884**	64.962	31.224	32.3179	76.986	**41.77533**
0.57	**38.7584**	**33.29**	66.122	31.782	32.1797	69.946	**44.69953**
0.58	**39.4384**	**32.716**	67.282	32.339	32.0502	64.787	**47.57088**
0.59	**40.1184**	**32.162**	68.442	32.897	31.9287	60.815	**50.41486**
0.6	**40.7984**	**31.626**	69.602	33.455	31.8145	57.646	**53.24782**
0.61	**41.4783**	**31.107**	70.762	34.012	31.7069	55.05	**56.08092**
0.62	**42.1583**	**30.605**	71.922	34.57	31.6056	52.878	**58.92216**
0.63	**42.8383**	**30.12**	73.082	35.127	31.5099	51.032	**61.77746**
0.64	**43.5182**	**29.649**	74.242	35.685	31.4195	49.44	**64.65134**
0.65	**44.1982**	**29.193**	75.402	36.243	31.3339	48.052	**67.54733**
0.66	**44.8782**	**28.75**	76.562	36.8	31.2529	46.83	**70.46822**
0.67	**45.5582**	**28.321**	77.722	37.358	31.176	45.745	**73.41629**
0.68	**46.2381**	**27.905**	78.882	37.915	31.103	44.776	**76.39338**
0.69	**46.9181**	**27.5**	80.042	38.473	31.0337	43.903	**79.40106**
0.7	**47.5981**	**27.108**	81.202	39.03	30.9677	43.114	**82.4406**
0.71	**48.278**	**26.726**	82.362	39.588	30.9049	42.397	**85.5131**
0.72	**48.958**	**26.355**	83.522	40.146	30.8451	41.742	**88.61951**
0.73	**49.638**	**25.994**	84.682	40.703	30.788	41.141	**91.76061**
0.74	**50.318**	**25.642**	85.842	41.261	30.7336	40.588	**94.93711**
0.75	**50.9979**	**25.3**	87.002	41.818	30.6815	40.078	**98.14962**
0.76	**51.6779**	**24.968**	88.163	42.376	30.6318	39.605	**101.3987**
0.77	**52.3579**	**24.643**	89.323	42.933	30.5842	39.166	**104.6847**
0.78	**53.0379**	**24.327**	90.483	43.491	30.5386	38.757	**108.0082**
0.79	**53.7178**	**24.019**	91.643	44.049	30.4949	38.376	**111.3694**
0.8	**54.3978**	**23.719**	92.803	44.606	30.4531	38.019	**114.7688**

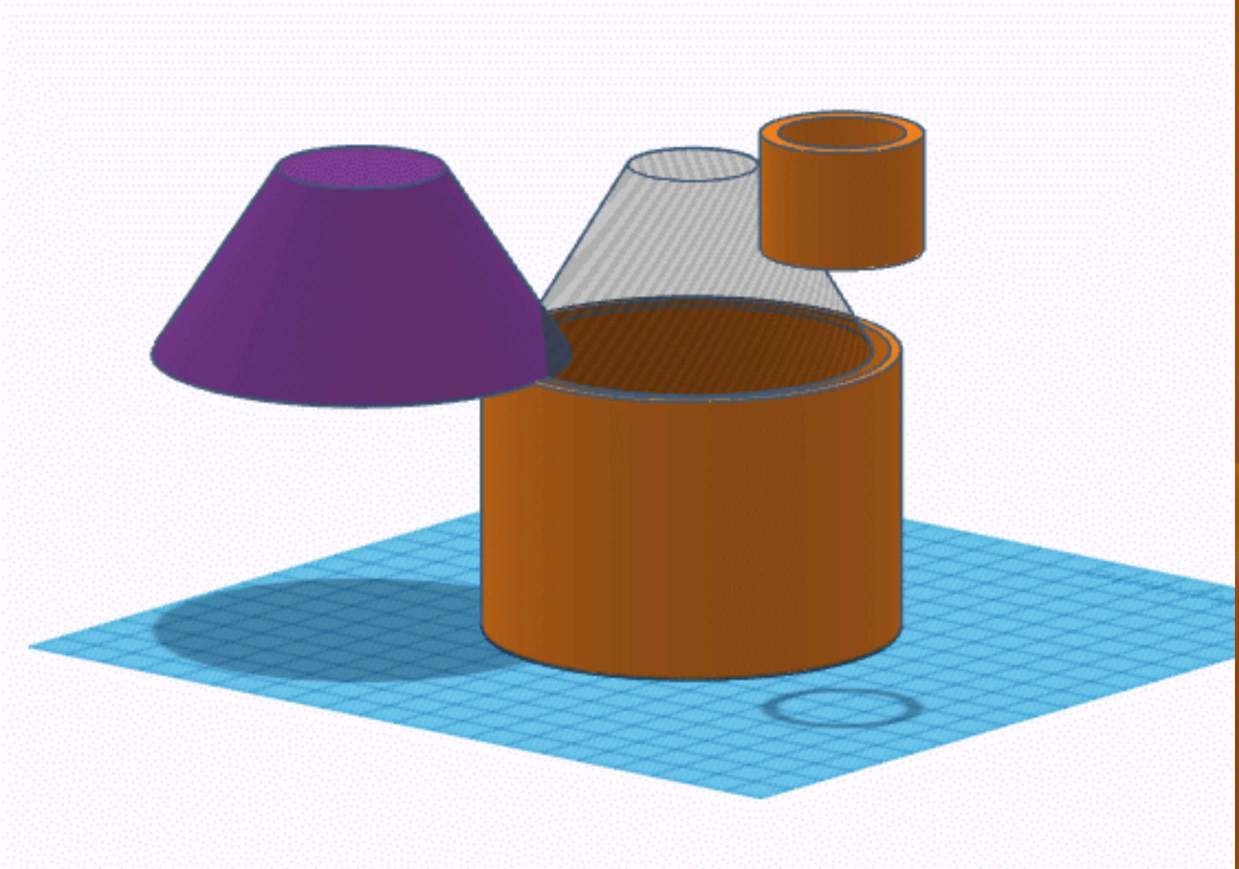
My Steps to making 3D feed

1) Assemble a design from primative shapes
2) Once assembled, save a .STL file of feed
3) Use 3D printer’s included software to make a printable file for your machine
4) I insert micro-SD card with file into printer
5) Print up part(s)
6) Tape things up

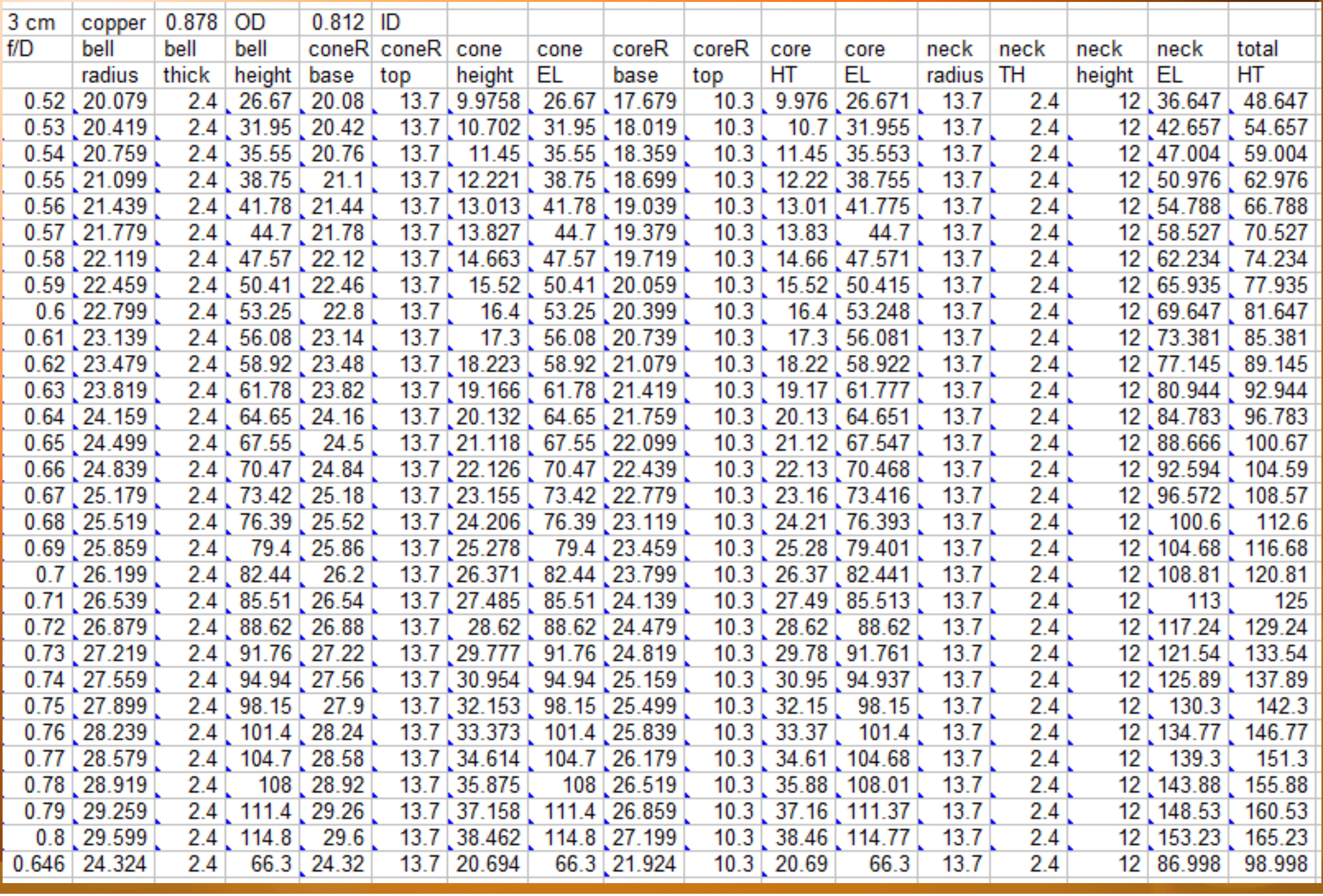
I use the free website Tinkercad.com to build designs from primative shapes (cones and hollow cylinders or rings)


3D design Daring Maimu-Esboo
tinkercad.com/things/IEbaPvNARvS-daring-maimu-esboo/edit
feedparts
Import
Export
Send To
TOP
RIGHT
Workplane
Basic Shapes
Settings
Snap Grid 1.0 mm

Making a W2IMU feed requires just 4 parts: a large ring for the “bell”, a small ring for the “neck”, a cone to connect them and a “hollow” cone for the interior

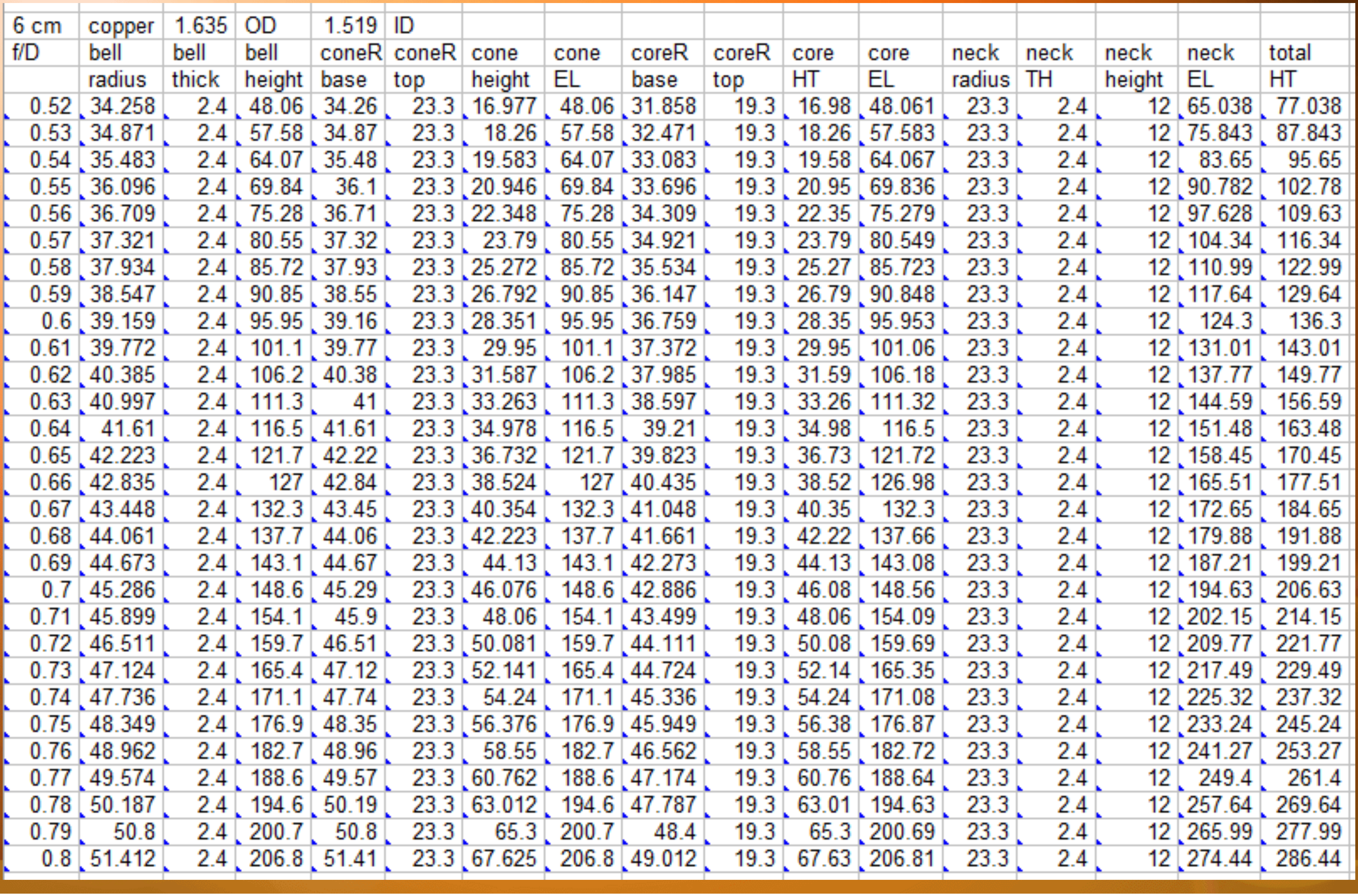


10 Ghz dimensions US 3/4" M pipe



3 cm	copper	0.878	OD	0.812	ID											
f/D	bell radius	bell thick	bell height	coneR base	coneR top	cone height	cone EL	coreR base	coreR top	core HT	core EL	neck radius	neck TH	neck height	neck EL	total HT
0.52	20.079	2.4	26.67	20.08	13.7	9.9758	26.67	17.679	10.3	9.976	26.671	13.7	2.4	12	36.647	48.647
0.53	20.419	2.4	31.95	20.42	13.7	10.702	31.95	18.019	10.3	10.7	31.955	13.7	2.4	12	42.657	54.657
0.54	20.759	2.4	35.55	20.76	13.7	11.45	35.55	18.359	10.3	11.45	35.553	13.7	2.4	12	47.004	59.004
0.55	21.099	2.4	38.75	21.1	13.7	12.221	38.75	18.699	10.3	12.22	38.755	13.7	2.4	12	50.976	62.976
0.56	21.439	2.4	41.78	21.44	13.7	13.013	41.78	19.039	10.3	13.01	41.775	13.7	2.4	12	54.788	66.788
0.57	21.779	2.4	44.7	21.78	13.7	13.827	44.7	19.379	10.3	13.83	44.7	13.7	2.4	12	58.527	70.527
0.58	22.119	2.4	47.57	22.12	13.7	14.663	47.57	19.719	10.3	14.66	47.571	13.7	2.4	12	62.234	74.234
0.59	22.459	2.4	50.41	22.46	13.7	15.52	50.41	20.059	10.3	15.52	50.415	13.7	2.4	12	65.935	77.935
0.6	22.799	2.4	53.25	22.8	13.7	16.4	53.25	20.399	10.3	16.4	53.248	13.7	2.4	12	69.647	81.647
0.61	23.139	2.4	56.08	23.14	13.7	17.3	56.08	20.739	10.3	17.3	56.081	13.7	2.4	12	73.381	85.381
0.62	23.479	2.4	58.92	23.48	13.7	18.223	58.92	21.079	10.3	18.22	58.922	13.7	2.4	12	77.145	89.145
0.63	23.819	2.4	61.78	23.82	13.7	19.166	61.78	21.419	10.3	19.17	61.777	13.7	2.4	12	80.944	92.944
0.64	24.159	2.4	64.65	24.16	13.7	20.132	64.65	21.759	10.3	20.13	64.651	13.7	2.4	12	84.783	96.783
0.65	24.499	2.4	67.55	24.5	13.7	21.118	67.55	22.099	10.3	21.12	67.547	13.7	2.4	12	88.666	100.67
0.66	24.839	2.4	70.47	24.84	13.7	22.126	70.47	22.439	10.3	22.13	70.468	13.7	2.4	12	92.594	104.59
0.67	25.179	2.4	73.42	25.18	13.7	23.155	73.42	22.779	10.3	23.16	73.416	13.7	2.4	12	96.572	108.57
0.68	25.519	2.4	76.39	25.52	13.7	24.206	76.39	23.119	10.3	24.21	76.393	13.7	2.4	12	100.6	112.6
0.69	25.859	2.4	79.4	25.86	13.7	25.278	79.4	23.459	10.3	25.28	79.401	13.7	2.4	12	104.68	116.68
0.7	26.199	2.4	82.44	26.2	13.7	26.371	82.44	23.799	10.3	26.37	82.441	13.7	2.4	12	108.81	120.81
0.71	26.539	2.4	85.51	26.54	13.7	27.485	85.51	24.139	10.3	27.49	85.513	13.7	2.4	12	113	125
0.72	26.879	2.4	88.62	26.88	13.7	28.62	88.62	24.479	10.3	28.62	88.62	13.7	2.4	12	117.24	129.24
0.73	27.219	2.4	91.76	27.22	13.7	29.777	91.76	24.819	10.3	29.78	91.761	13.7	2.4	12	121.54	133.54
0.74	27.559	2.4	94.94	27.56	13.7	30.954	94.94	25.159	10.3	30.95	94.937	13.7	2.4	12	125.89	137.89
0.75	27.899	2.4	98.15	27.9	13.7	32.153	98.15	25.499	10.3	32.15	98.15	13.7	2.4	12	130.3	142.3
0.76	28.239	2.4	101.4	28.24	13.7	33.373	101.4	25.839	10.3	33.37	101.4	13.7	2.4	12	134.77	146.77
0.77	28.579	2.4	104.7	28.58	13.7	34.614	104.7	26.179	10.3	34.61	104.68	13.7	2.4	12	139.3	151.3
0.78	28.919	2.4	108	28.92	13.7	35.875	108	26.519	10.3	35.88	108.01	13.7	2.4	12	143.88	155.88
0.79	29.259	2.4	111.4	29.26	13.7	37.158	111.4	26.859	10.3	37.16	111.37	13.7	2.4	12	148.53	160.53
0.8	29.599	2.4	114.8	29.6	13.7	38.462	114.8	27.199	10.3	38.46	114.77	13.7	2.4	12	153.23	165.23
0.646	24.324	2.4	66.3	24.32	13.7	20.694	66.3	21.924	10.3	20.69	66.3	13.7	2.4	12	86.998	98.998

6cm using 1.5 inch “M” copper

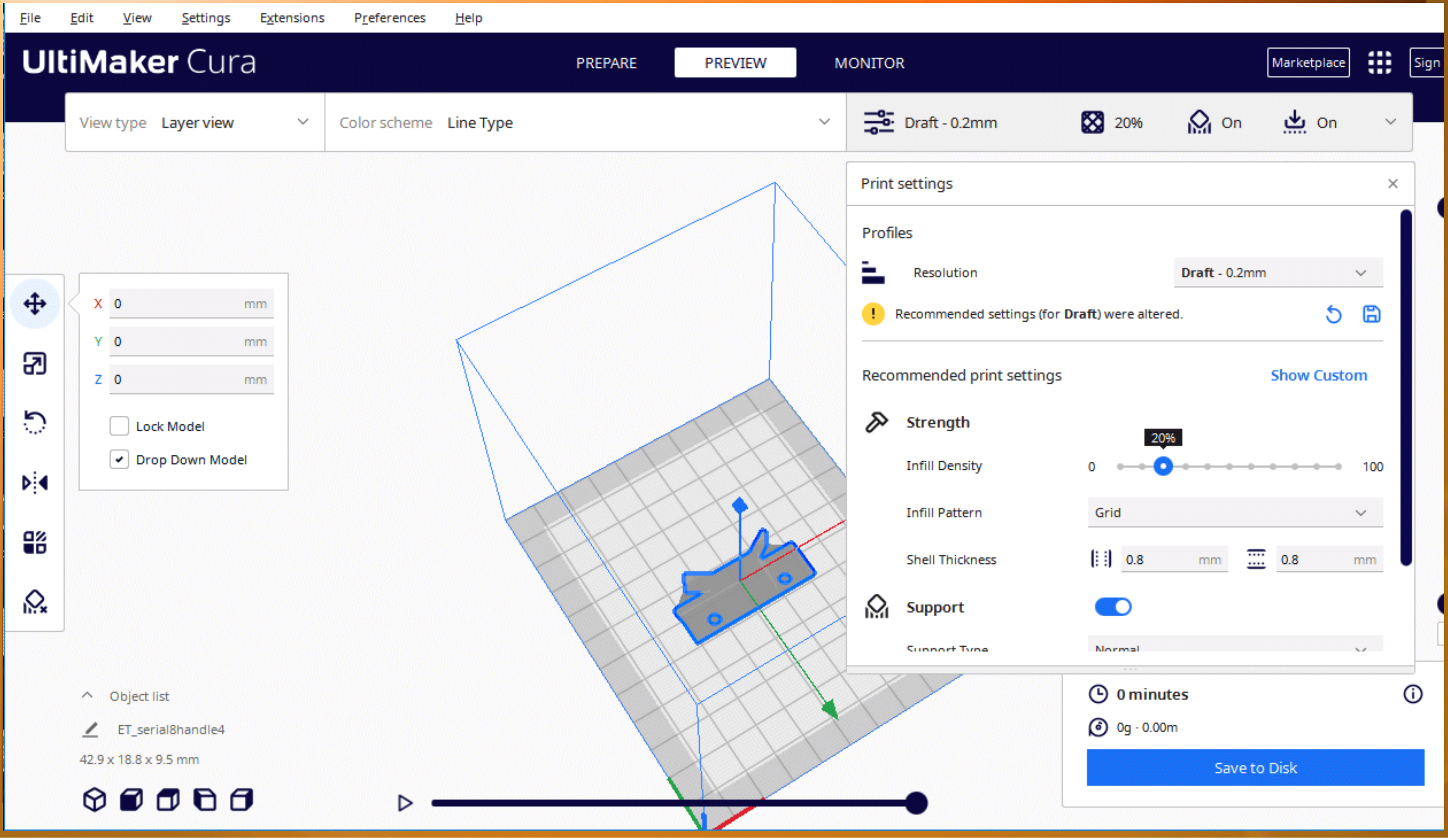


6 cm	copper	1.635	OD	1.519	ID											
f/D	bell	bell	bell	coneR	coneR	cone	cone	coreR	coreR	core	core	neck	neck	neck	neck	total
	radius	thick	height	base	top	height	EL	base	top	HT	EL	radius	TH	height	EL	HT
0.52	34.258	2.4	48.06	34.26	23.3	16.977	48.06	31.858	19.3	16.98	48.061	23.3	2.4	12	65.038	77.038
0.53	34.871	2.4	57.58	34.87	23.3	18.26	57.58	32.471	19.3	18.26	57.583	23.3	2.4	12	75.843	87.843
0.54	35.483	2.4	64.07	35.48	23.3	19.583	64.07	33.083	19.3	19.58	64.067	23.3	2.4	12	83.65	95.65
0.55	36.096	2.4	69.84	36.1	23.3	20.946	69.84	33.696	19.3	20.95	69.836	23.3	2.4	12	90.782	102.78
0.56	36.709	2.4	75.28	36.71	23.3	22.348	75.28	34.309	19.3	22.35	75.279	23.3	2.4	12	97.628	109.63
0.57	37.321	2.4	80.55	37.32	23.3	23.79	80.55	34.921	19.3	23.79	80.549	23.3	2.4	12	104.34	116.34
0.58	37.934	2.4	85.72	37.93	23.3	25.272	85.72	35.534	19.3	25.27	85.723	23.3	2.4	12	110.99	122.99
0.59	38.547	2.4	90.85	38.55	23.3	26.792	90.85	36.147	19.3	26.79	90.848	23.3	2.4	12	117.64	129.64
0.6	39.159	2.4	95.95	39.16	23.3	28.351	95.95	36.759	19.3	28.35	95.953	23.3	2.4	12	124.3	136.3
0.61	39.772	2.4	101.1	39.77	23.3	29.95	101.1	37.372	19.3	29.95	101.06	23.3	2.4	12	131.01	143.01
0.62	40.385	2.4	106.2	40.38	23.3	31.587	106.2	37.985	19.3	31.59	106.18	23.3	2.4	12	137.77	149.77
0.63	40.997	2.4	111.3	41	23.3	33.263	111.3	38.597	19.3	33.26	111.32	23.3	2.4	12	144.59	156.59
0.64	41.61	2.4	116.5	41.61	23.3	34.978	116.5	39.21	19.3	34.98	116.5	23.3	2.4	12	151.48	163.48
0.65	42.223	2.4	121.7	42.22	23.3	36.732	121.7	39.823	19.3	36.73	121.72	23.3	2.4	12	158.45	170.45
0.66	42.835	2.4	127	42.84	23.3	38.524	127	40.435	19.3	38.52	126.98	23.3	2.4	12	165.51	177.51
0.67	43.448	2.4	132.3	43.45	23.3	40.354	132.3	41.048	19.3	40.35	132.3	23.3	2.4	12	172.65	184.65
0.68	44.061	2.4	137.7	44.06	23.3	42.223	137.7	41.661	19.3	42.22	137.66	23.3	2.4	12	179.88	191.88
0.69	44.673	2.4	143.1	44.67	23.3	44.13	143.1	42.273	19.3	44.13	143.08	23.3	2.4	12	187.21	199.21
0.7	45.286	2.4	148.6	45.29	23.3	46.076	148.6	42.886	19.3	46.08	148.56	23.3	2.4	12	194.63	206.63
0.71	45.899	2.4	154.1	45.9	23.3	48.06	154.1	43.499	19.3	48.06	154.09	23.3	2.4	12	202.15	214.15
0.72	46.511	2.4	159.7	46.51	23.3	50.081	159.7	44.111	19.3	50.08	159.69	23.3	2.4	12	209.77	221.77
0.73	47.124	2.4	165.4	47.12	23.3	52.141	165.4	44.724	19.3	52.14	165.35	23.3	2.4	12	217.49	229.49
0.74	47.736	2.4	171.1	47.74	23.3	54.24	171.1	45.336	19.3	54.24	171.08	23.3	2.4	12	225.32	237.32
0.75	48.349	2.4	176.9	48.35	23.3	56.376	176.9	45.949	19.3	56.38	176.87	23.3	2.4	12	233.24	245.24
0.76	48.962	2.4	182.7	48.96	23.3	58.55	182.7	46.562	19.3	58.55	182.72	23.3	2.4	12	241.27	253.27
0.77	49.574	2.4	188.6	49.57	23.3	60.762	188.6	47.174	19.3	60.76	188.64	23.3	2.4	12	249.4	261.4
0.78	50.187	2.4	194.6	50.19	23.3	63.012	194.6	47.787	19.3	63.01	194.63	23.3	2.4	12	257.64	269.64
0.79	50.8	2.4	200.7	50.8	23.3	65.3	200.7	48.4	19.3	65.3	200.69	23.3	2.4	12	265.99	277.99
0.8	51.412	2.4	206.8	51.41	23.3	67.625	206.8	49.012	19.3	67.63	206.81	23.3	2.4	12	274.44	286.44

Even a small child can understand the basic idea of stacking round parts together to make a 3D feed

(It helps if she is a very smart small child)

My 3D printer uses “slicing” software called “Cura”. It imports the .STL file downloaded from Tinkercad and makes a “gcode” file.



View type Layer view

Color scheme Line Type

Draft - 0.2mm 20% On On

X 0 mm

Y 0 mm

Z 0 mm

☐ Lock Model

☑ Drop Down Model

Print settings

Profiles

Resolution **Draft** - 0.2mm

Recommended settings (for **Draft**) were altered.

Recommended print settings

Show Custom

Strength

Infill Density 0 20% 100

Infill Pattern Grid

Shell Thickness 0.8 mm 0.8 mm

Support ●

Support Type Normal

Object list

ET_serial8handle4

42.9 x 18.8 x 9.5 mm

0 minutes

0g · 0.00m

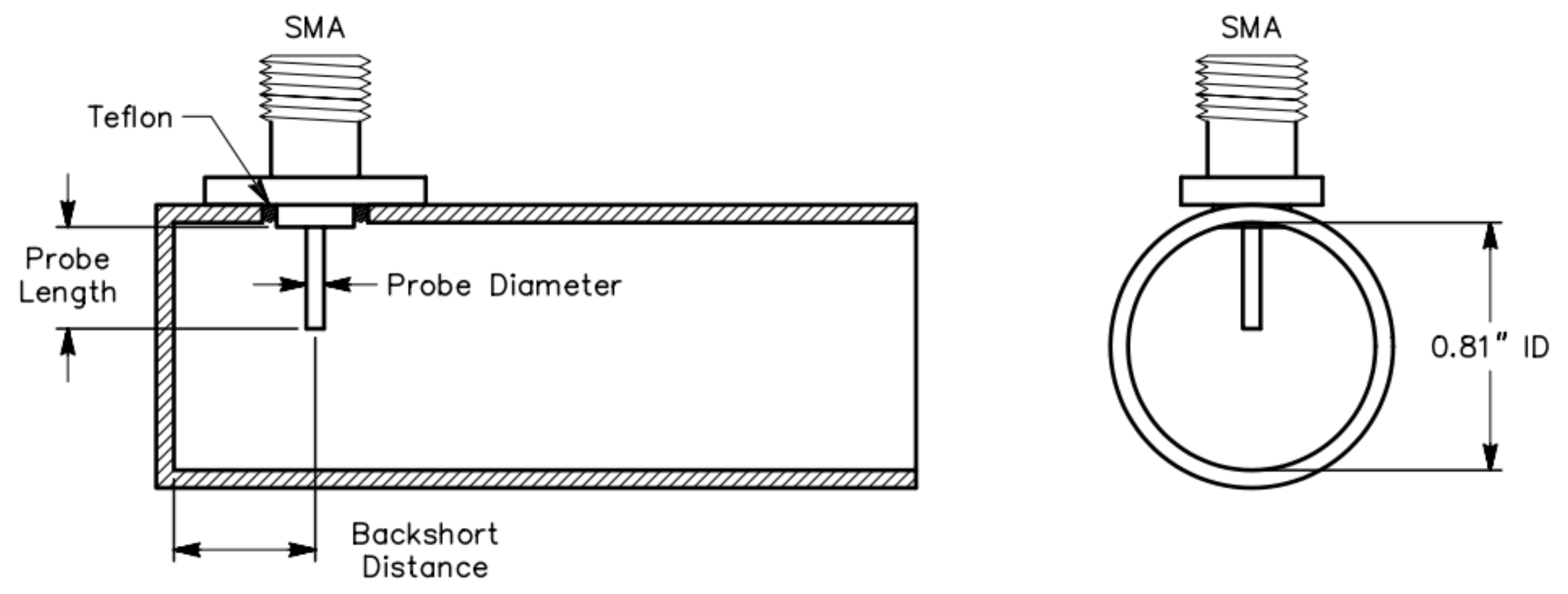
Save to Disk

MY printer is small: 100 x 100 x 100

... also cheap at about $170

Now for the Copper part

(SMA to copper TRANSITION design compliments of W1GHZ's work on 10 Ghz copper waveguides 2001)



Probe length is 0.25 inches and Back-distance is 10.9-12.4mm

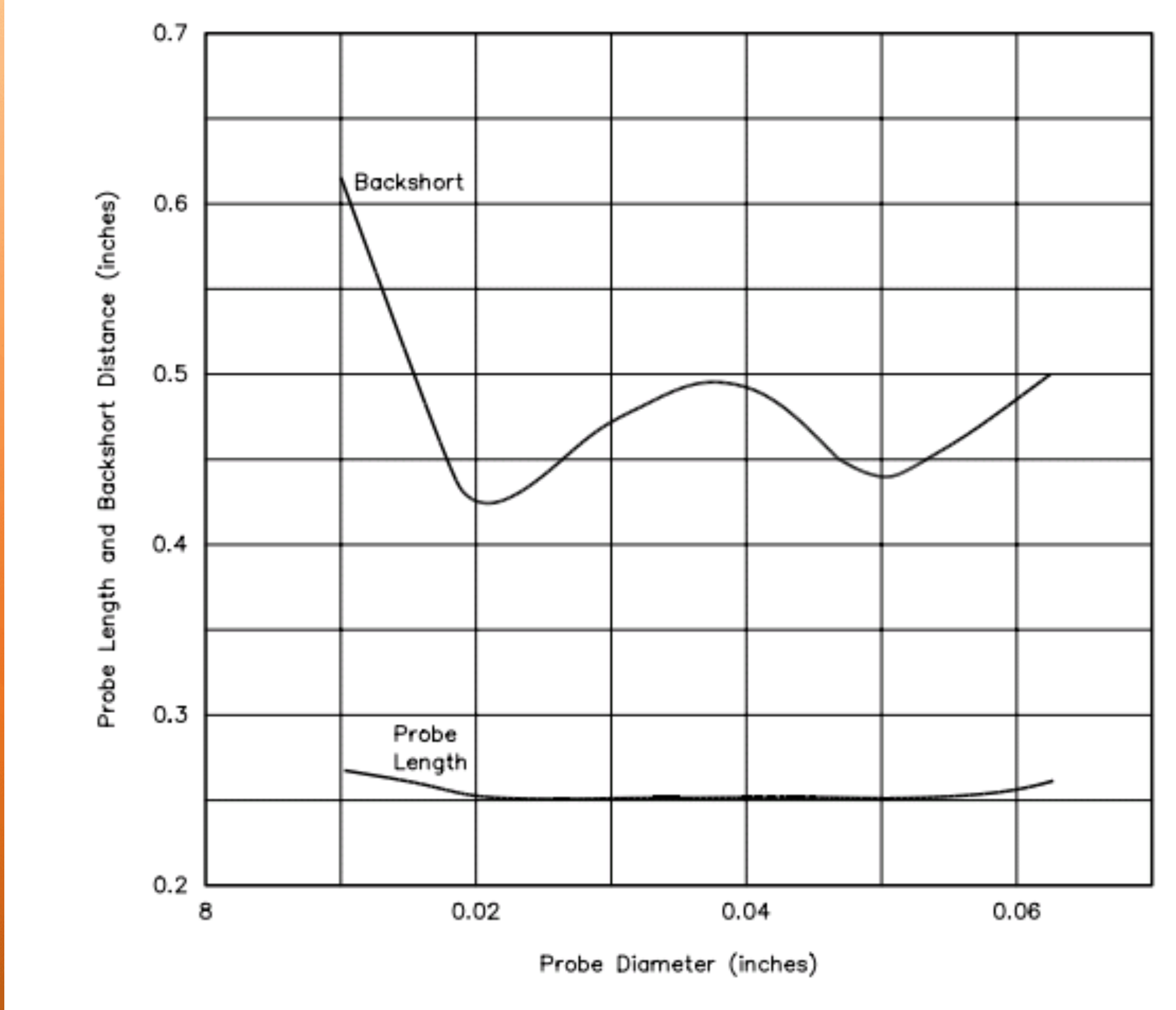


Fig 17—Circular waveguide-to-coax transition—best dimensions.

- Copper tube in US is 3/4" type M

- copper disks of 7/8"

- SMA connector with teflon base and
center conductor

Cost to make these feeds?

Copper pipe $10/ two feet	$1.00 ea
SMA connector $8/5	$1.60 ea
PLA filament $16/ 12	$1.33 ea
Copper tape $10/10	$1.00 ea
Copper end cap $26/ 24	$1.08 ea

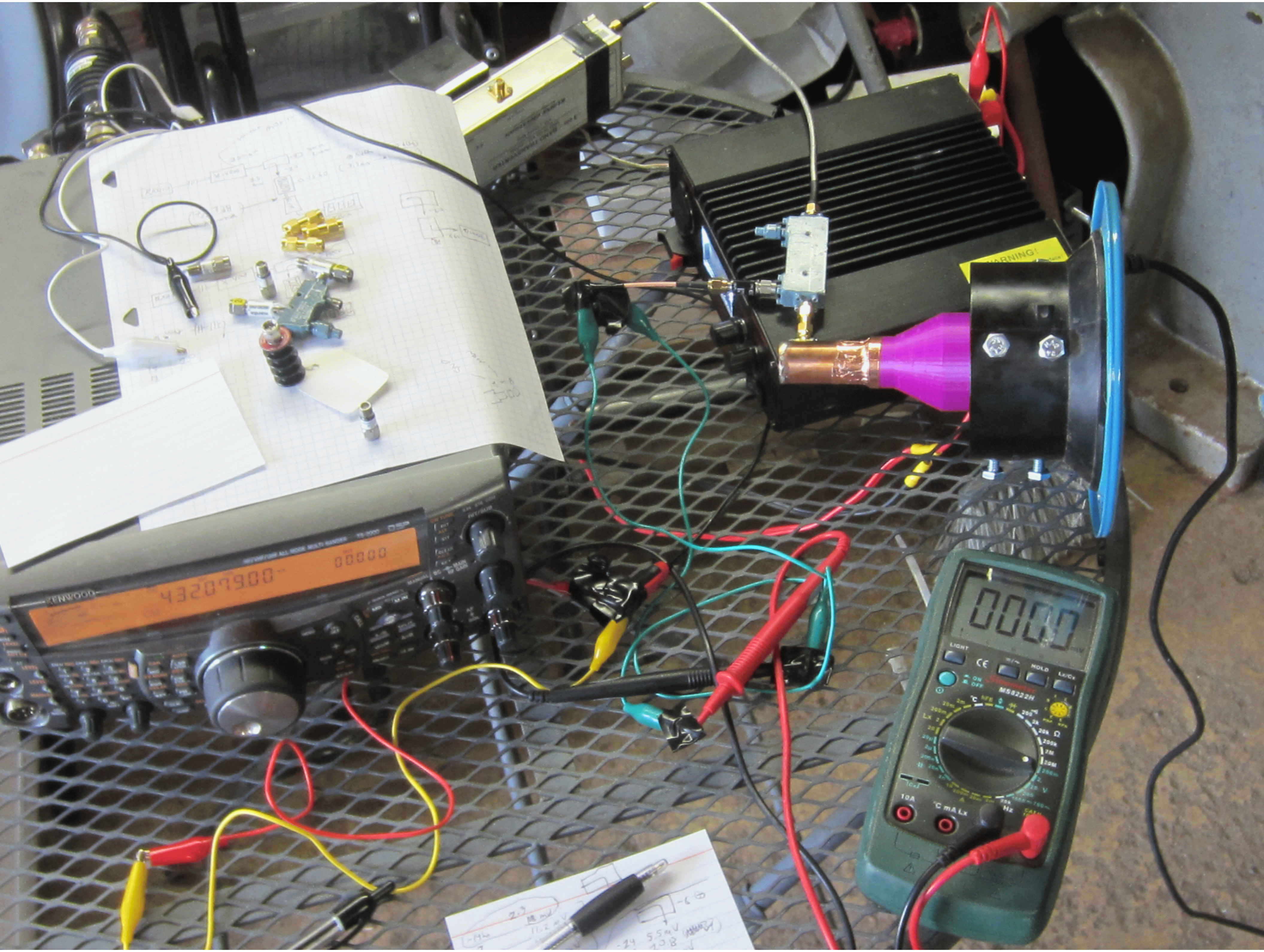
That is either $6.01 to make a feed or $70, depending upon how you look at it!

What is the performance?

I don’t really know

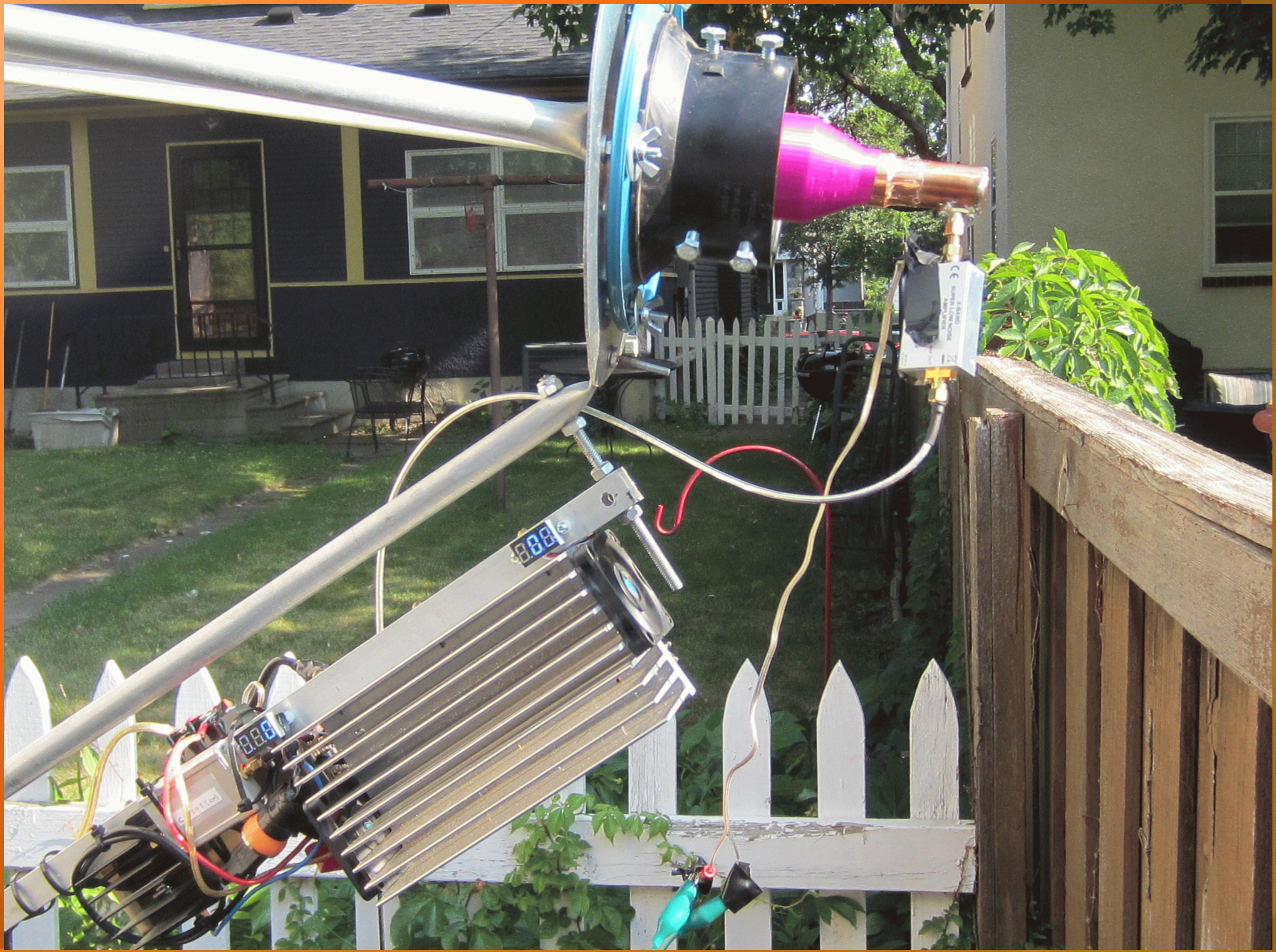
My test gear for 10 Ghz consists of my transverter, some directional couplers, numerous attenuators, some detector diodes and my DVM.

So I can get an idea of SWR / reflected power...


KENWOOD
43207900
00000
WARNING!
0000
MS8222H

Stick it in the dish and point to the sun!

Y with 6' dish
RFH: 6.6
W2IMU: 8.4
Ext. 8" dish
.68 IMU: 10.2
.51 IMU: ??



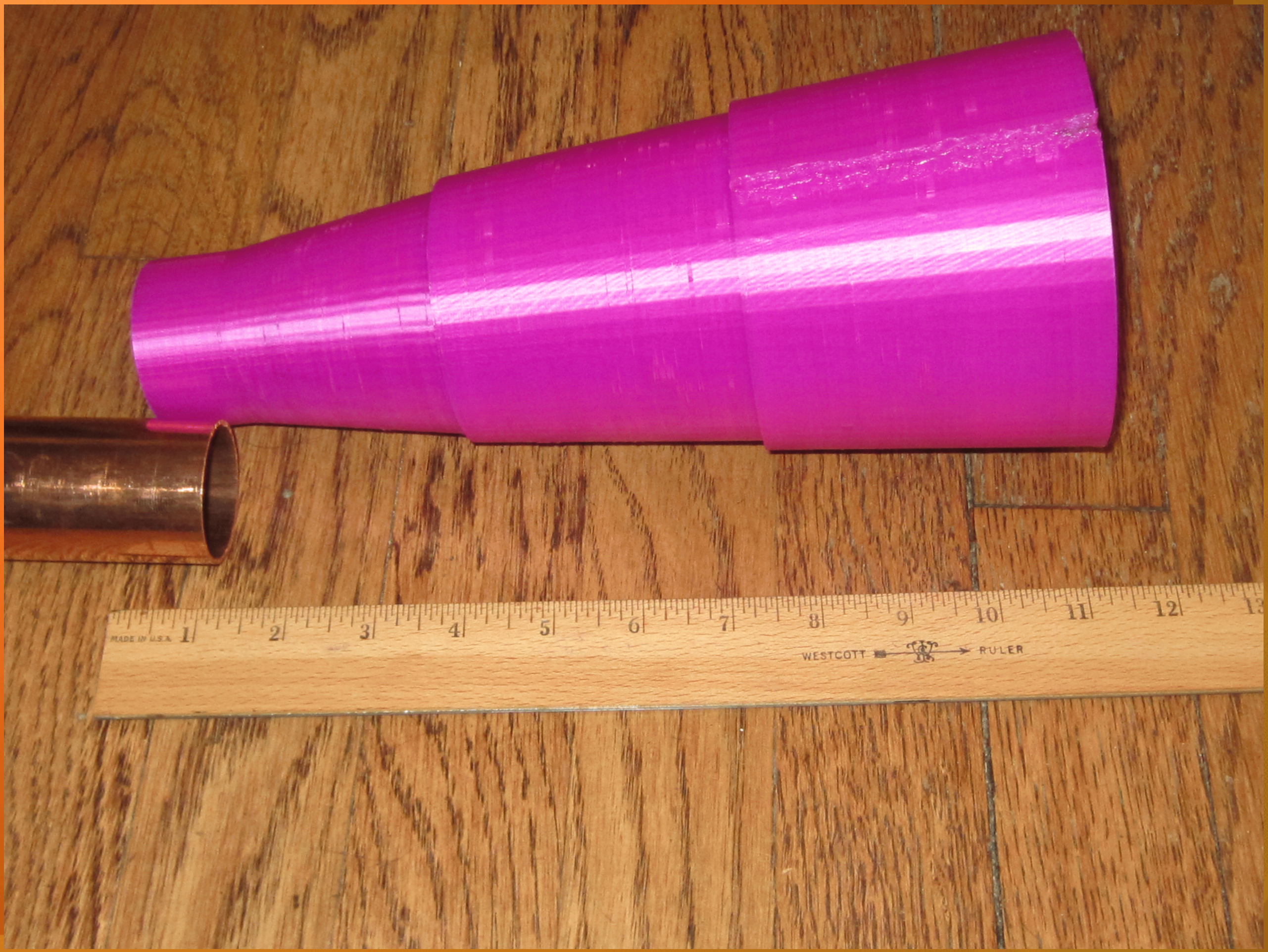
What else can one do?

Even with a small printer, parts can be “welded” or taped together

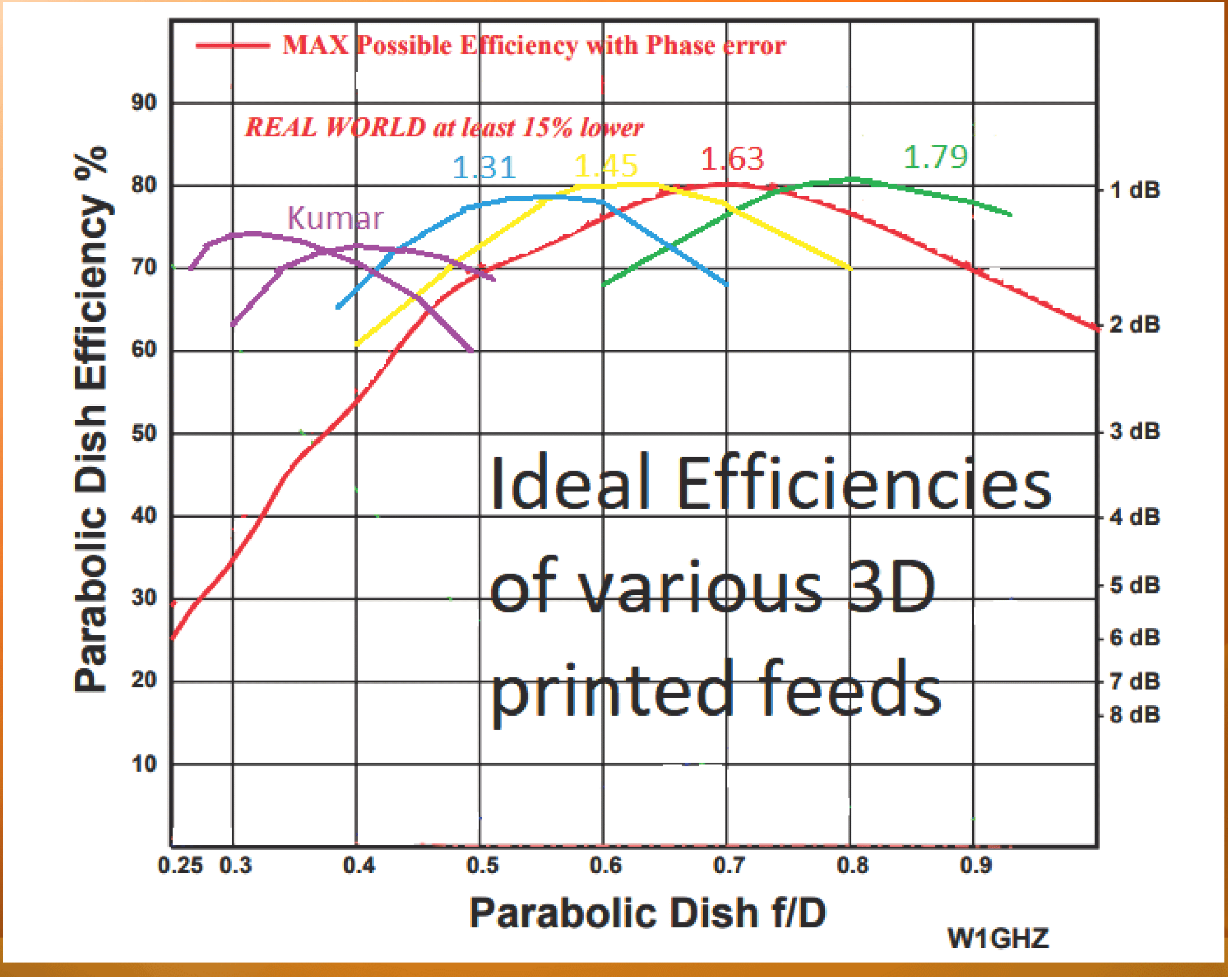
This is a 6 cm Skobelev type

feed for f/D=0.9 made up from 4 parts

(From W1GHZ optimum feeds)



The same simple copper transition can be fit into many different 3D feeds



Summary of usefullness

- Small feeds for upper bands
- Cost? (+/-) LOW COST if you have a printer now!
- Can’t find appropriate size of copper
- For experimentation - swap units in/out
- If you have a “unique” design
- If you need feed now but are planning to expand dish later
- If you are using half of a big dish for upper bands and need feed for the resulting high f/D
- If you are so compulsive that you need feed for 0.457 f/D dish -EXACTLY

ANY EASY QUESTIONS?